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BIBLIOGRAPHY ON TIDAL HYDRAULICS

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Tidal Flows in Rivers and Harbors

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Contents

Preface

Report No. 2, "Bibliography on Tidal Hydraulics" and Supplements 1-10 thereto were published by the Committee on Tidal Hydraulics in 1954, 1955, 1957, 1959, 1965, 1968, 1971, 1975, 1980, 1985, and 1987, respectively, in connection with certain of its objectives. This supplement consists of 775 references on the subject and includes both current and older references which have been accumulated. References not indicated by a dagger (†) are available for loan within the continental United States from the Research Library, U.S. Army Engineer Waterways Experiment Station (WES).

This supplement follows the same form as the original bibliography and consists of eight sections, each preceded by a brief statement of its scope. As a further convenience to the user, the references are arranged alphabetically under each subject matter heading (section), and all have been annotated. Although the majority of the references appear in more than one section, the complete entry appears only once—under the most applicable subject heading—with other listings giving only author, date, title, and key for its location.

Copies of this report may be obtained from the Committee on Tidal Hydraulics, care of U.S. Army Engineer Waterways Experiment Station, ATTN: CEWES-IM-MI-R, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199.

This supplement was compiled by Katherine M. Kennedy, Librarian (Engr), Research Library, Management Information Division, Information Technology Laboratory (ITL), WES, under the general supervision of Mr. Frank A. Herrmann, Jr., Director, Hydraulics Laboratory (HL), and Chairman, Committee on Tidal Hydraulics. Recognition is made of the following persons who provided assistance on this supplement: Marsha C. Gay, editor, Editorial Section, Visual Production Center, ITL, and George M. Fisackerly, Chief, Estuarine Processes Branch, Estuaries Division, HL, who reviewed this report for contents and classification.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander and Deputy Director was COL Bruce K. Howard, EN.

SECTION I. THEORETICAL CONSIDERATIONS

Basic principles of tidal hydraulics, including the mechanics and types of tides, height and time of tide, tide-producing forces, tidal currents, theories, cubature techniques, predictions, computations, estuarine circulation, and meteorological effects.

†**Agnew, D. C.** 1984. Sea level variations and ocean dynamics in the Aleutian Islands, 1 August-30 April 1983. San Diego, CA: Institute of Geophysics and Planetary Physics, California University.

The overall purpose of this project was to study ocean dynamics along the Aleutian Island chain, which is the boundary between the North Pacific Ocean and the Bering Sea. These two bodies of water communicate through a number of straits (usually called passes) which are shallowest at the eastern end. The specific goal of this project was to use pre-existing data sets, particularly long time series of sea level and meteorology, to understand something of the physical oceanography of the area. Particular questions of interest included the following. Tidal dynamics: how do the tides propagate along the chain and through the passes? Why is there an anomalously small S2 tide in the Bering Sea? What is the flux of tidal energy into the Bering Sea, and how is it distributed along the chain? Other sea level variations: how does atmospheric forcing affect low-frequency sea level changes? Are other low-frequency signals present that could be correlated with shelf waves or with changes in currents such as the Alaskan Stream near the island chain? Is there any nonlinear interaction between tides and sea level? Can any pattern of meteorology be associated with the harbor seiches observed in some of the tide records? This report presents what results were obtained: in all cases they are preliminary rather than final.

†**Aiyesimoju, K. O.** 1986. Numerical prediction of transient water quality in estuarine/river networks. (See complete entry in Section VI.)

Al-Bakri, D. 1986. Provenance of the sediments in the Humber Estuary and the adjacent coasts, eastern England. (See complete entry in Section II.)

Amin, M. 1987. A method for approximating the nodal modulations of real tides. *The International Hydrographic Review* 64(2):103-113.

A simple method for approximating the nodal modulations of tidal constituents generated in shallow waters is described. The changes in the nodal modulations from their equilibrium values are found to be mostly due to bottom friction. In this method, functional approximations of interaction coefficients are obtained with the help of resolved nonlinear tides of frictional origin. New nodal terms and contributions to the nodal terms of gravitational origin are estimated by using the interpolated values of interaction coefficients for respective frequencies. Four years of observations can provide a reasonably accurate estimate of nodal terms and nodal modulations as such, which normally requires at least 18.6 years of observations. Tidal predictions are shown to be quantitatively improved when newly derived modulations are used in place of the conventional equilibrium modulations. (10 refs)

Amin, M. 1986. On the conditions for classification of tides. *The International Hydrographic Review* 63(1):161-174.

This investigation is carried out to examine the conditions which are commonly used to classify a tidal regime as diurnal or semidiurnal. It is observed that the application of COURTIER'S criterion in tidal predictions is not always appropriate. It is shown that during some neap tides most of the major tidal harmonics of the semidiurnal band may conspire to oppose the M_2 tide. Consequently, at some ports the semidiurnal component may degenerate into a dodge tide. Under these circumstances, though a tide may be classified as semidiurnal according to Courtier's criterion, the tidal profile is determined by the constituents of the other species. A diurnal tide can occasionally become semidiurnal for similar reasons. A simple mathematical explanation of these conditions and when they are likely to occur is given. For practical purposes, new conditions that must be satisfied for a tide to be diurnal or semidiurnal during the full spring-neap cycle are suggested. (6 refs)

Anderson, F. E., and Meyer, L. M. 1986. The interaction of tidal currents on a disturbed intertidal bottom with a resulting change in particulate matter quantity, texture and food quality. (See complete entry in Section II.)

Anderson, G. F. 1986. Silica, diatoms and a freshwater productivity maximum in Atlantic coastal plain estuaries, Chesapeake Bay. (See complete entry in Section III.)

Andrews, J. C., Dunlap, W. C., and Bellamy, N. F. 1984. Stratification in a small lagoon in the Great Barrier Reef. (See complete entry in Section III.)

Apelt, C. J. 1980. A decade of hydraulics in Australasia. In *7th Australasian conference on hydraulics and fluid mechanics,* 18-22 August 1980, Brisbane, Australia, 1-8. Barton, Australia: The Institution of Engineers, Australia.

Research and developments in hydraulics in Australia during 1968-80 are reviewed. The survey covers hydraulic structures, waterhammer, open channel flow, estuaries, and flows with density differences. The impacts of the marriage of fundamental fluid mechanics to hydraulic design and of computers are reviewed and shown to be extensive in all areas surveyed. Several topics are identified as requiring much more attention than they have received in the past, particularly the field of energy loss in open channel flows. (73 refs)

Ashley, G. M., and Grizzle, R. E. 1988. Interactions between hydrodynamics, benthos and sedimentation in a tide-dominated coastal lagoon. (See complete entry in Section II.)

Badenhorst, P. 1986. Effect of dredging on estuarine environments, alternative disposal sites and dredging guidelines. (See complete entry in Section V.)

Baker, E. T. 1984. Patterns of suspended particle distribution and transport in a large fjordlike estuary. *Journal of Geophysical Research* 89(C4):6553-6566.

Seasonal and spatial patterns of the distribution and transport of suspended particles in Puget Sound, a large fjordlike estuary, are a product of the interaction of the subtidal circulation with surface and bottom particle sources. The particle distribution differs from the distribution of hydrographic properties and is characterized by four persistent features: (a) a thin (<10 m), high-turbidity surface layer, (b) a thick (~ 50 m), low-turbidity zone centered around the level of no net motion between net seaward and landward flow, (c) horizontal particle fronts at the sill entrances, and (d) a bottom nepheloid layer maintained by local resuspension. Removal of particles from the surface waters by advective downwelling at the seaward sill and gravitational settling throughout the basin make Puget Sound an efficient particle trap. Particles sedimented on the basin floor are transported preferentially landward by the action of erosion/deposition cycles enhanced by fortnightly intrusions of new marine water. (39 refs)

Baker, T. F., Edge, R. J., and Jeffries, G. 1982. High precision tidal gravity; Final report, 1 April 1980-31 March 1982. (See complete entry in Section VII.)

†**Bales, J. D.** 1986. Field and numerical studies of tracer gas transport and surface gas transfer in laterally uniform, partially stratified estuaries. (See complete entry in Section VI.)

Banal, M. 1989. Tidal energy in 1989 (L'énergie marémontrice en 1989). (See complete entry in Section V.)

Barthe, X., and Castaing, P. 1989. Theoretical study of the action of tidal currents and swell on the sediments of the continental shelf of the Bay of Biscay (Étude théorique de l'action des courants de marée et des houles sur les sédiments du plateau continental de Golfe de Gascogne). (See complete entry in Section II.)

Barwell, L. 1988. Dynamics of the Palmiet River mouth. CSIR Report EMA-T 8802. Stellenbosch, South Africa: Division of Earth, Marine and Atmospheric Science and Technology, Council for Scientific and Industrial Research.

A synthesis of available data on the existing state of the Palmiet estuary mouth is provided in the form of a baseline technical report. It includes information on the hydrology, wind regime, aeolian transport, wave regime, sediment movement, and mouth stability as well as an analysis of historical changes. (5 refs)

Bedford, K. W. 1985. Selection of turbulence and mixing parameterizations for estuary water quality models. (See complete entry in Section VI.)

†**Berger, T. J.** 1987. A simple numerical model for the study of baroclinic estuarine shelf interactions. (See complete entry in Section VI.)

Bernshtein, L. B. 1988. From experimental to large tidal power stations (20th anniversary of the Kislogubsk tidal power station). (See complete entry in Section VI.)

†**Besnier, G.** 1983. Equipment of the estuary of the Vilaine; Building of Arzal Dam (L'amenagement de l'estuaire de la Vilaine; Construction du Barrage d'Arzal). (See complete entry in Section V.)

†**Bickerton, I. B., Heydorn, A. E. F., and Grindley, J. R., ed.** 1982. Estuaries of the Cape; Part 2: Synopses of available information on individual systems; Report No. 15: Zeekoe (CSW 5). Stellenbosch, South Africa: National Research Institute for Oceanology.

Information is summarized on various aspects of the Zeekoe estuaries of the Cape region of the Republic of South Africa. Among the topics discussed are

rivers, public health, land ownership and use, water pollution, plants, and animals.

Bliek, A. J., Klatter, H. E., Konter, J. L. M., and van der Meulen, T. 1986. Short cut channels in tidal estuaries. (See complete entry in Section V.)

Blumberg, A. F. 1978. The influence of density variations on estuarine tides and circulations. (See complete entry in Section VI.)

Bodge, K. R., and Dean, R. G. 1987. Short-term impoundment of longshore sediment transport. (See complete entry in Section II.)

Boersma, J. R., and Terwindt, J. H. J. 1981. Neapspring tide sequences of intertidal shoal deposits in a mesotidal estuary. *Sedimentology* 28(2):151-170.

The hydrographic properties, the distribution and response pattern of various types of bed forms, and the sedimentary structures produced were observed in the mesotidal Westerschelde Estuary, The Netherlands. Ebb and flood tides generally differed in strength; the resulting dominance changed over the neap-spring tide period. Parallel, long-crested sand waves and irregular short-crested dunes responded differently to the neap-spring variation in current velocity. The internal structure largely consisted of unidirectional cross-bedding, separated into a succession of tidal bundles, each formed during one tide. These tidal bundles were arranged in a lateral sequence reflecting neap-spring tide periods and differed in character with location. Within the tidal bundle, reactivation, full vortex, and slackening structures reflected acceleration, full stage, and deceleration of flow, respectively, in the dominant tide, usually the flood tide. The full vortex structures tended to be well developed around spring tide and disappear toward neap tide. The subordinate tide carved pause planes which enclose the tidal bundles. These pause planes can be either erosional or depositional. (20 refs)

†**Bogdanov, K. T., and Kharkov, B. V.** 1975. Calculation of Indian Ocean tides. (See complete entry in Section VIII.)

Boggs, S., Jr., and Jones, C. A. 1976. Seasonal reversal of flood-tide dominant sediment transport in a small Oregon estuary. (See complete entry in Section II.)

Böhm, E., Magazzu, G., Wald, L., Zoccolotti, M-L. 1987. Coastal currents on the Sicilian shelf south of Messina. *Oceanological Acta* 10(2):137-142.

The dynamics of a coastal current flowing on the eastern shelf of Sicily are investigated by means of hydrological data and satellite-derived imagery. Strong tidal mixing occurring near the sill of the Strait of Messina generates a water mass whose hydrological characteristics are intermediate between Levantine and Atlantic waters. This water mass flows southward along the Sicilian coast as far as 100 km from the sill and as far offshore as 10 km. It therefore affects a major part of the eastern coast of Sicily. Furthermore, this current can become unstable and display meanders and eddies. (8 refs)

†**Bonnefille, R.** 1980-81. Residual phenomena in estuaries. *Oceanis* 6(4):343-357.

The theory of residual phenomena, based on the elimination by averaging of tide-alternating effects, is introduced. When applied to estuaries in a two-dimensional system, the original circulations are revealed, the main parameters being the river discharge and the salinity gradient along the estuary. The main manifestation of these phenomena is the appearance of closed circulations near the bottom which prevent the seaward evacuation of suspended matter. Data on the Gironde estuary (France) were used to estimate the eddy dispersal coefficients which model the residual phenomena. The application of these theories of the temperature distribution indicates that in an estuary the difference between bottom and surface temperature rarely exceeds 0.5° to 1° C.

Bose, S. K., Ray, P., and Dutta, B. K. 1987. Mathematical models for mixing and dispersion in forecasting and management of estuarine water quality. *Water Science and Technology* 19(9):183-193.

The dispersion or spread of a dissolved or suspended substance in an estuarine system occurs due mainly to the nonuniformity of velocity distribution, including turbulent fluctuations, shear stress at the boundary, and surface stress caused by winds. The mixing and dispersion phenomena in rivers and estuaries are extremely important in water quality management and control. The development of a dispersion model in harmony with the nature of the flow field in a river or estuary is necessary in the estimation and

correlation of dispersion parameters, called dispersion coefficients, which may, in general, be anisotropic in a multidimensional transport process. The earlier one-dimensional models have gradually given way to higher dimensional models for better description of the phenomena as well as for more accurate estimation of parameters. Field studies of dispersion of tracers have been the most important method of generating data for parameter estimation. A number of correlations for mixing and dispersion coefficients in terms of flow rates and other fundamental system parameters are available. The present study incorporates the analysis, assessment, and applications of various dispersion and mixing models available. Also, a critical appraisal of the validity, inherent degree of uncertainty, and the range of applications of different correlations have been incorporated. (64 refs)

Bottin, R. R., Jr., Outlaw, D. G., and Seabergh, W. C. 1985. Effects of proposed harbor modifications on wave conditions, harbor resonance, and tidal circulation at Fish Harbor, Los Angeles, California; Physical and numerical model investigations. (See complete entry in Section VI.)

Bowden, K. F. 1984. Turbulence and mixing in estuaries. In *The estuary as a filter*, ed. V. S. Kennedy, 15-26. Orlando: Academic Press.

Mixing and dispersion in an estuary result from a combination of advective and diffusive processes and are closely related to patterns of circulation. The intensity and scale of turbulence depend largely on the stability of the density distribution and so affect directly the vertical fluxes of momentum and matter. Indirectly, the state of turbulence also influences the longitudinal and transverse mixing. In setting up models to predict changes in estuarine conditions arising from natural external causes or human intervention, most attention in the past has been given to longitudinal fluxes across planes perpendicular to the axis of an estuary. The apparent simplicity of one-dimensional treatments, often used for this purpose, conceals the importance of contributions from physical processes in the vertical and transverse directions. It is likely that two- and three-dimensional models will be more widely used in future but their successful employment calls for a better understanding of the physical processes which are to be simulated. (19 refs)

Bowman, M. J., Kibblewhite, A. C., Murtagh, R. A., Chiswell, S. M., and Sanderson, B. G. 1983. Circulation and mixing in Greater Cook Strait, New Zealand. *Oceanologica Acta* 6(4):383-391.

The shelf seas of Central New Zealand are strongly influenced by both wind and tidally driven circulation and mixing. The region is characterized by sudden and large variations in bathymetry; winds are highly variable and often intense. Cook Strait canyon is a mixing basin for waters of both subtropical and subantarctic origins. During weak winds, patterns of summer stratification and the loci of tidal mixing fronts correlate well with the h/u^3 stratification index. Under increasing wind stress, these prevailing patterns are easily upset, particularly for winds blowing to the southeasterly quarter. Under such conditions, slope currents develop along the North Island west coast which eject warm, nutrient-depleted subtropical water into the surface layers of the strait. Coastal upwelling occurs on the flanks of Cook Strait canyon in the southeastern approaches. Under storm-force winds to the south and southeast, intensifying transport through the Strait leads to increased upwelling of subsurface water occupying Cook Strait canyon at depth. This spreads seaward as a cool, nutrient-laden mesoscale plume $\sim 10^4$ km^2 in area. It is suggested that this source of nutrients may have an important influence on the long streamers of apparent phytoplankton patches which stretch southeastward in the Pacific Ocean from the mouth of the strait. Satellite imagery has identified a large ($\sim$100-km diameter) anticyclonic eddy which may permanently occupy the deep slope waters east of the southeastern approaches. (31 refs)

†**Boynton, J. E.** 1985. The influence of current velocity on nutrient and oxygen exchanges between estuarine sediments and the water column. (See complete entry in Section II.)

Bratkovick, A. 1985. Aspects of the tidal variability observed on the southern California continental shelf. *Journal of Physical Oceanography* 15(3):225-239.

Observations of the current and temperature field from the southern California continental shelf are analyzed in a frequency band (0.6-6 cpd) dominated by tidal fluctuations. The seasonal variability of the temperature and horizontal velocity component fields for this frequency band is characterized both in terms of mean variance statistics and changes in the power spectra. The most striking seasonally varying feature is the $0(10^2)$ increase in tidal band temperature variance observed from winter to summer on the inner shelf. Energetic cuspate peaks are observed centered

at 1, 2, 3 and 4 cpd. The bandwidth of the peaks is approximately 0.2 cpd giving a decorrelation time of 5 days for tidally induced current and velocity component fluctuations. A complex empirical eigenfunction analysis indicates that the amplitude and phase of coherent structures in the velocity component and temperature fields vary over vertical and horizontal spatial scales comparable to the local depth and shelf width, respectively. The most energetic modes vary in spatial structure with frequency. The first mode semidiurnal (diurnal) fluctuations tend to be bottom (surface) intensified. The estimated vertically averaged cross-shelf mass transport associated with semidiurnal and diurnal cross-shelf currents is sufficient to sustain tidal sea surface elevation changes. The total cross-shelf mass exchange is approximately three times larger than the vertically averaged mass flux at tidal frequencies. Estimates of the bulk Richardson number indicate the vertical current shears associated with baroclinic fluctuations in the tidal frequency band are of sufficient magnitude to induce a marginally stable baroclinic flow field on the shelf. (31 refs)

Briscoe, M. G. 1984. Tides, solitons and nutrients. *Nature* 312(5989):15.

Tidal energy mixes the coastal waters, providing nutrients for biological processes. The mechanism is indirect; the topography of the shelf break, the stratification of the coastal waters, and the tides interact to produce groups of solitons--strong, short, high-frequency internal waves--and it is the breaking of these solitons as they propagate inshore to even shallower water that is responsible for the mixing. It is proposed that the surface tides at the shelf edge are converted to internal tides and then to solitons that dissipate on the shelf. (4 refs)

Broche, P., Salomon, J. C., Demaistre, J. S., and Devenon, J. L. 1986. Tidal currents in Baie de Seine: Comparison of numerical modelling and high-frequency radar measurements. (See complete entry in Section VI.)

Brown, R. D. 1982. Ocean tide measurement by Seasat altimeter data. (See complete entry in Section VIII.)

Brown, W. D., and Trask, R. P. 1980. A study of tidal dissipation and bottom stress in an estuary. *Journal of Physical Oceanography* 10(11):1742-1754.

A method for inferring an area-averaged bottom stress and energy dissipation rate in a tidal estuarine channel is presented. The one-dimensional continuity and momentum relations are developed using simplifying assumptions appropriate for a well-mixed shallow and narrow estuary. The finite-difference form of these relations is derived for a section of the Great Bay Estuary, New Hampshire, an estuary which has been shown to have a relatively large energy dissipation rate. A set of current, bottom-pressure and sea-level measurements from the estuary is used to estimate time series of all important first- and second-order terms in the momentum equation. Except near slack water, it is found that the instantaneous first-order balance must be between the surface-slope-induced pressure gradient and bottom-stress forces. Important second-order contributions to the balance come from the inertial and convective acceleration terms. Time series of bottom stress are inferred by summing the estimated terms. For this study site the 14-day root mean square (rms) bottom stress is 45.1 ± 4.5 dyn cm^{-2} with a corresponding rms and mean dissipation rate of 3,526 $\pm$420 and 2,478 $\pm$297 ergs cm^{-2} S^{-1}, respectively. The role of the first-order tidal motion and nonlinearities in the mean second-order force balance is discussed. (18 refs)

Butler, H. L. 1986. Advanced numerical models for coastal currents and sediment transport. (See complete entry in Section VI.)

Câmara, A. S., da Silva, M. Cardoso, Ramos, L., and Ferreira, J. G. 1967. Tejo 1--An interactive program for the division of estuaries into homogeneous areas. (See complete entry in Section VI.)

Cannon, G. A., Bretschneider, D. E., and Holbrook, J. R. 1984. Transport variability in a fjord. (See complete entry in Section II.)

Cartwright, D. E. 1985. Tidal prediction and modern time scales. *The International Hydrographic Review* 62(1):127-138.

Modern time scales introduced since about 1950 and revised formulas for the mean lunar and solar longitudes are defined and compared with the formulas of NEWCOMB and BROWN, which still form the basis of current tide prediction practice. Changes in tidal arguments of order 0°.02 are identified, with a tendency to increase towards the 21st century. Small changes in potential amplitude and speed of some leading harmonic constituents from AD 1900 to 2000 are also noted. While all changes are small by tidal standards, it is recommended that the modern

formulas be adopted by tidal authorities before discrepancies become noticeable. The modern formulas require at least an approximate correction for the difference between Dynamic or Ephemeris Time and Civil or Universal Time, which will probably exceed 1 minute before AD 2000. (16 refs)

Cartwright, D. E., and Amin, M. 1986. The variances of tidal harmonics. (See complete entry in Section VIII.)

Catewicz, Z. 1985. On the variability of currents in the coastal zone of the African shelf at 16° North. *Deutsche Hydrographische Zeitschrift* 38(2):69-92.

In the period from May 1980 until the end of January 1981, an experiment was carried out in the shallow-water area of the West African Shelf off Saint Louis. During the investigation the seasonal variation of currents was observed, the current phenomena then being characterized by various intensities and flow directions. The most important period is that from December to May, when the currents are emphatically affected by trade winds. Characteristic for this period are the southward flow direction and high velocities from the range of 15 to 33 cm/sec. Strong turbulence anisotropy occurs in the zone under consideration. The values of the turbulence intensity in most cases exceed unity; it is thus impossible to apply Taylor's hypothesis of "frozen turbulence." The exchange coefficients, calculated by means of the Lettau-Ertel method, are in general in the range of 10^5 to 10^6 cm^2/sec. The ellipses of momentum horizontal exchange, related to the directions of extreme exchange, are characterized by anisotropy, where the parameter ($p = a/b$) (a, b are ellipse axes) ranges from 3 (at 1 km from the shore) to 2 (at 3 km from the shore), with $p = 2.5$ at 2 km from the shore. The current spectral analysis has indicated the domination of the oscillations with the semidiurnal tidal period. Moreover, there occur maxima related to the diurnal tide, also the maxima with the period of 54, 44 to 41, 21, and 17 hours. The water-level harmonic analysis has indicated the occurrence in this region of the tide of semidiurnal, regular type. On the other hand, the currents there are of semidiurnal, irregular type. The mean value of the amplitudes of the semidiurnal tidal currents is diversified; as for the periods chosen, the value of 2 ($M_2 + S_2$) ranges from 2.1 to 5.4 cm/sec, whereas for the whole measuring period these amplitudes are somewhat smaller. The shift of the tidal current maximum with respect to the sea-level maximum in the coastal zone is slight, ranging from 0.2 to 0.7 h before high water (16 refs)

Central Board of Irrigation and Power. 1988. Tidal power development. (See complete entry in Section VI.)

†Chabert D'Hieres, G., and Le Provost, C. 1977. Synthesis of determinations of the principal tidal components in the English Channel, resolved with the aid of the Grenoble scale model. *Annales Hydrographiques* 5(1):47-55 (In French).

Following the previous Franco-Soviet oceanography symposium when the principle of detailed studies of the main spectral components of tides in the English Channel was explained, recent years have seen the application of this principle; and it has been possible to define almost every significant component: diurnal, semidiurnal of astronomical and radioactive origin, semidiurnal of nonlinear origin, fourth diurnal, and sixth diurnal. This paper attempts a synthetic presentation of this detailed information and regroups the various components into distinct groups within which the waves have similar characteristics which may be determined theoretically.

Chaloin, B., Péchon, P., and Coëffé, Y. 1985. Hydraulic studies of the bed evolution of the River Canche Estuary and of the Dunkirk Harbour extensions. (See complete entry in Section VI.)

†Chaoyu, W. 1986. A dynamics and sedimentology study of eastern Atchafalaya Bay, Louisiana. (See complete entry in Section II.)

†Chatterjee, A. K., and Debnath, L. 1980. Mathematical model for flood and embankment prediction in a tidal river. *Acta Mechanica* 36(3/4):187-194.

The authors present application of one-dimensional Saint Venant equations integrated in an explicit finite difference scheme using classic development proposed by Dronkers. The reviewer made a number of such applications and found these schemes equally adequate for analysis of tidal flows in estuaries. Results are presented as curves of maximum water-surface elevation for each riverine discharge, and hydrographs of water elevations versus time. Tidal influence progresses further upriver with decrease in freshwater flow. The authors state that the scheme may be applied to interlacing channels. The reviewer has applied such a scheme to treelike systems with tributaries, but found out that interlacing channels which result in islands are better treated with network analysis using "node" expression for continuity equation. The reviewer assumes that the boundary condition at the confluence with the

Hooghly River, India, was well defined from existing records. Otherwise, the model should have included this channel with the boundary condition defined at sea.

†**Chatterjee, A. K., and Debnath, L.** 1978. Study of nonlinear wave propagation in tidal rivers. (See complete entry in Section VI.)

†**Chen, C.-L.** 1985. Simulation of hydrodynamics and water quality in a well-mixed estuary by using finite element methods. (See complete entry in Section VI.)

Cheng, R.-T. 1986. Modeling of estuarine hydrodynamics—A mixture of art and science. (See complete entry in Section VI.)

†**Cheng, R. T., and Walters, R. A.** 1982. Modelling of estuarine hydrodynamics and field data requirements. (See complete entry in Section VI.)

†**Chevereau, C., and De Sogreah, M.** 1977. Mathematical models applied to the study of morphological processes and pollutant propagation in coastal regions. (See complete entry in Section VI.)

Chu, W.-S., Barker, B. L., and Akbar, A M. 1988. Modeling tidal transport in the Arabian Gulf. (See complete entry in Section VI.)

Chu, Y.-H., and Chen, H. S. 1985. Bechevin Bay, Alaska, inlet stability study. (See complete entry in Section VI.)

Church, J. A., and Forbes, A. M. G. 1983. Circulation in the Gulf of Carpentaria. I: Direct observations of currents in the south-east corner of the Gulf of Carpentaria. *Australian Journal of Marine and Freshwater Research* 34(1):1-10.

Data from three current-meter moorings in the south-east corner of the Gulf of Carpentaria indicate that barotropic diurnal tidal currents are predominant. The low-passed currents are also barotropic, but there is not a good correlation between the currents at the three moorings or with the wind recorded at Mornington Island. This may be due to the existence of topographic gyres in the residual currents, or the winds recorded at Mornington Island not being representative of those at the moorings sites. (18 refs)

Cialone, M. A. 1986. Yaquina Bay, Oregon, tidal and wave-induced currents near the jettied inlet; Numerical model investigation. (See complete entry in Section VI.)

Clarke, Allan J., and Battisti, David S. 1981. The effect of continental shelves on tides. *Deep-Sea Research* 28A(7):665-682.

Coastal tides are influenced by several factors and one of the most important of these is the character of the adjacent continental shelf. A continental margin theory is derived and used to discuss several different aspects of the effect "smooth" continental shelves have on tides. The main results are as follows. (a) The theory suggests, in accordance with observations, that semidiurnal tides should be amplified on wide shelves in mid and low latitudes, but that diurnal tides should not be amplified. (b) Continental shelf tidal resonance occurs when the shelf scale $g\alpha/(\omega^2 - f^2)$(α = shelf bottom slope, ω = tidal frequency) is approximately equal to the shelf width. Theoretical arguments and observation can be used to show that shelf resonance occurs, for example, along sections of the northwest Australian shelf. (c) Given the easily obtained coastal tide, theory shows that tides over the continental shelf and slope can be approximately estimated analytically. Calculations using simple prediction formulas can be made on a hand calculator. Subject to some restrictions, a simple and inexpensive method is thus available for estimating barotropic tides on continental shelves. (d) An appropriate boundary condition for global numerical tidal models, which cannot resolve the continental margin region, is derived. For the diurnal tides, the boundary condition can be well approximated by an impermeable wall condition at the deep-sea continental slope boundary. For the semidiurnal tides, the impermeable wall condition usually, but not always, suffices; it can break down on wide continental shelves. (22 refs)

Coenen, R. C. A. 1986. Water quality management for the Dutch sector of the North Sea. *Water Pollution Control* 85(2):200-207.

The need for a water quality management concept emerged from an inventory in 1982 of conflicts between uses of the North Sea and of the present sectoral policy decision on North Sea matters in The Netherlands. The policy scheme primarily focuses on the quality of water and, secondly, on the quality of sediments and organisms. The planning area is defined as the Dutch continental shelf limited by the high tide mark. Sources of pollution outside the planning area but relevant for the water quality inside the planning area are taken into account. A

predominant hydrological factor in the southern part of the North Sea is the tidal influence. Apart from the intensive transport of sand in the sea, small particles of clay silts of marine and riverine origin circulate in some parts of the North Sea, and often precipitate in estuaries and other net-sedimentation areas such as the Waddensea. The salinity varies in the coastal zone, due to the freshwater inputs.

Collins, M. B., and Ferentinos, G. 1984. Residual circulation in the Bristol Channel, as suggested by Woodhead sea-bed drifter recovery patterns. *Oceanologica Acta* 7(1):33-42.

Woodhead sea-bed drifters were released from 11 stations in the Bristol Channel. Recoveries ranged between 51 and 68 percent of those released at each station. Drifter transport paths are inferred on the basis of geographical recoveries and elapsed times. The suggested near-bed residual water circulation pattern represents seaward and landward transport in midchannel and along the coastal zones, respectively; it is consistent with numerically predicted frictionally driven tidal current residuals. Landward transport of water in the coastal zone of the Bristol Channel provides a possible explanation from upstream transfer of fine-grained sediments. Such a mechanism might be more generally applicable to other estuarine systems. (40 refs)

Costa, S. L., Landsteiner, M. C., Stork, J. W., and Gould, T. C. 1982. Discharge-displacement calculations for tidal flushing. (See complete entry in Section VIII.)

Craig, P. D. 1987. Solutions for internal tidal generation over coastal topography. *Journal of Marine Research* 45(1):83-105.

Internal tides may be described by a hyperbolic equation which, for the case of constant buoyancy frequency, has constant coefficients. The equation is solved by using the characteristic geometry and characteristic functions to establish a set of linear algebraic equations in the model amplitudes. The accuracy of the solutions can be assessed using energy considerations. The capability of the solution technique is demonstrated by simulating the barotropic generation of internal waves over linear topography, with emphasis on near-critical topography, when the solution exhibits high shears and discontinuous behavior at the critical slope. The structure of the waves is determined by the ratio, α, of the bottom slope to characteristic slope. The magnitude of the waves may be estimated by considering the ratio of the baroclinic to the topographic length scales which, for linear slopes, is also given by α. For supercritical slopes, the offshore energy flux varies approximately linearly with α, while for subcritical slopes it varies as α^5. (17 refs)

Crickmore, M. J. 1982. Data collection -- Tides, tidal currents and suspended sediment. (See complete entry in Section VII.)

Curtis, R. J. 1985. Tidal recirculation of dredge spoil: Major sedimentary process in Lyttelton Harbour, South Island, New Zealand. (See complete entry in Section II.)

Davies, A. M. 1985. A three-dimensional model of the northwest European continental shelf, with application to the M_4 tide. (See complete entry in Section VI.)

Davis, R. A., Jr., Knowles, S. C., and Bland, M. J. 1989. Role of hurricanes in the Holocene stratigraphy of estuaries: Examples from the Gulf Coast of Florida. *Journal of Sedimentary Petrology* 59(6):1052-1061.

Sarasota and Little Sarasota Bays are shallow, coastal bays located landward of a Holocene barrier/inlet complex on the west-central, microtidal Gulf coast of Florida. Sediments presently accumulating in the bay consist of (a) fine to very fine quartz sand contributed from the Gulf shoreline during storm-generated washover, through tidal inlets, and from reworking of older deposits; (b) fine sand to pebble-sized quartz and phosphatic sediment contributed by Tertiary and Pleistocene deposits; (c) biogenic carbonate debris which is produced within the bays and/or derived from the Gulf of Mexico; (d) clay minerals derived from weathering of Tertiary and Pleistocene carbonates and clays; and (e) particulate organic debris. Interpretations from 51 vibracores from throughout the bays have enabled delineation of four major depositional sedimentary facies resulting from specific environmental conditions: protected bay, open bay, tidal delta/washover, and storms. Bedrock in the area ranges from 0 to about -8 m MSL and is largely responsible for the areal configuration of the bay and the location of the barrier islands. The Holocene stratigraphy of both bays has been greatly influenced by the passage of major hurricanes which carried large volumes of sand and shell gravel into the bays. At least four of these storms are documented in these cores. Three storm units from Sarasota Bay have been radiocarbon dated at 2,270, 1,320 and 240 years before present (YBP).

Historically documented severe hurricanes influenced this coast in 1848 and 1921. Hurricanes interrupted the normal, low-energy, slow deposition in the bays and caused inlets to open and close. Three storm-sedimentary facies are identified: (a) a graded storm facies which is composed of conspicuously fining upward units ranging from sandy shell-gravel to slightly shelly quartz sand, (b) a homogeneous storm facies consisting of homogeneous and relatively thin shelly-sand and gravel units, and (c) a fluvial storm facies which is muddy and generally free of shells representing terrigenous influx from runoff. (26 refs)

†**Debnath, L., and Chatterjee, A. K.** 1978. Nonlinear mathematical model of the propagation of tides in interlacing channels. (See complete entry in Section VI.)

†**Debnath, L., and Chatterjee, A. K.** 1981. Two dimensional nonlinear wave propagation in a shallow tidal estuary. (See complete entry in Section VI.)

de Boer, P. L., Oost, A. P., and Visser, M. J. 1989. The diurnal inequality of the tide as a parameter for recognizing tidal influences. *Journal of Sedimentary Petrology* 59(6):912-921.

Tidal periodicities, in particular the neap/spring/neap cycle, can be recognized in the internal structure of large-scale cross-bedded sets. Another frequently occurring periodicity is the diurnal inequality of the tide. This is a regular variation of the water levels reached by successive high and/or low waters in semidiurnal and mixed tidal systems. As a result, the strength of successive flood and ebb currents fluctuates. A particular depositional site in a tidal environment is frequently dominated by one of these two tidal currents. This can be reflected in the sediments in a bundle-wise building up of unidirectional cross-strata. During a dominant current stage, the bedform advances, and its displacement is reflected in the thickness of the forest deposits (bundles). The neap/spring sequence is reflected in variations of the bundle thickness over a period of 14 days. Variations in the strength of successive dominant currents due to the diurnal inequality of the tide are reflected in thick-thin variations in the thicknesses of successive bundles. The diurnal inequality of the tide occurs in semidiurnal tidal regimes and in the semidiurnal parts of mixed tidal systems. When the tidal currents within a semidiurnal or mixed tidal regime drop to such low magnitudes that bedform migration ceases, for example around neap tide, the number of bundles within a neap-spring cycle may be (much) less than 28, and the depositional system can be incorrectly interpreted as a "diurnal tidal system." Then the reflection of the diurnal inequality of the tide in the bundle thicknesses may reveal that bedform migration was subject to semidiurnal tides and that standstill periods in the bedform migration must have caused a reduction in the number of bundles per neap/spring cycle. Several examples from the recent literature are used to demonstrate this principle. In present-day diurnal systems the difference between low and high water is generally small and, moreover, the time span between low and high water is twice as long as in semidiurnal systems. The low tidal amplitude and the low frequency result in generally small tidal current velocities, which are rarely strong enough to produce large-scale megaripples with bundle cycles. Apart from the recognition of tidal influences in fossil sedimentary deposits, measurements of lunar cycles offer a tool for differentiating diurnal from semidiurnal and mixed tidal systems in the geological past. Changes in the earth-moon rotational system may also be recognized. (26 refs)

de Boer, P. L., van Gelder, A., and Nio, S. D., ed. 1988. *Tide-influenced sedimentary environments and facies.* (See complete entry in Section II.)

Dejak, C., Lalatta, I. M., Messina, E., and Pecenik, G. 1987. Steady-state achievement by introduction of true tidal velocities in a pollution model of the Venice Lagoon. (See complete entry in Section VI.)

Delft Hydraulics Laboratory. 1983. Mathematical modelling of estuarine phenomena. (See complete entry in Section VI.)

Delft Hydraulics Laboratory. 1986. Special issue on estuaries and coastal seas. (See complete entry in Section VI.)

de Mowbray, T., and Visser, M. J. 1984. Reactivation surfaces in subtidal channel deposits, Oosterschelde, Southwest Netherlands. *Journal of Sedimentary Petrology* 54(3):811-824.

Recognition of unsteadiness in flow velocities is an important factor in the identification of tidal deposits. One consequence of such unsteadiness is the production of reactivation surfaces-erosion surfaces developed within a cross-stratified set. Reactivation surfaces can be produced in a unidirectional flow system, by the migration of a faster-moving megaripple over a slower one ("overtaking"). The form of the surface is dependent upon the relative sizes of the

two megaripples concerned and the flow conditions under which they migrate. Other types of reactivation surfaces are produced by the action of a subordinate current, which erodes the lee side of the dominant-current megaripple. The morphology of the reactivation structures depends on the size of the megaripples concerned (the examples considered here had heights in the range 0.2-2.5 m) and, most importantly, on the relative strengths of the dominant and subordinate currents. Where the subordinate current is relatively weak, only the tops of the dominant-current foresets are eroded. With increasing subordinate-current strength, the whole foreset height is subjected to erosion, and a large angular discordance is produced between the large-scale foresets and the reactivation surface. Such strong erosion drastically alters the megaripple relief-the lee-side slope is much reduced. Recovery of the lee side during the subsequent dominant-current phase is gradual, as can be seen from the development of small-scale structures immediately overlying the reactivation surfaces. The regular variation in the strength of the subordinate current during the neap-spring cycle is often reflected in the morphology of the reactivation surfaces. In such examples, the reactivation surfaces formed during spring tide periods have a large angular discordance with the foresets, indicating that there was considerable erosion by the subordinate current. Reactivation surfaces formed during periods between spring and neap, in contrast, are developed only in the upper parts of the foresets, suggesting that subordinate-current erosion was relatively modest, while the deposits of the neap tides themselves show no evidence of any erosion by the subordinate current. (24 refs)

†**deSwart, H. E., and Zimmerman, J. T. F.** 1984. Tidal rectification in lateral viscous boundary layers of a semienclosed basin. Amsterdam, Netherlands: Center for Mathematics and Computer Science, Department of Applied Mathematics.

The rectified flow, induced by divergence of the vorticity flux in lateral oscillatory viscous boundary layers along the sidewalls of a semienclosed basin, is studied as a function of the Strouhal number, equivalent to the Reynolds number. It is shown that for small Strouhal numbers the ratio of the rectified flow and the tidal current amplitude is proportional to the number but for larger values the behavior is exponential. The latter conclusion is reached using a global renormalization of the vorticity equation.

†**De Young, B. S.** 1986. The circulation and internal tide of Indian Arm, B. C. Ph.D. diss., The University of British Columbia, Vancouver, BC, Canada.

The wintertime deepwater exchange in a silled fjord is described. Bottom-water renewal took place in the third year of the study, 1984-85. Hydraulic control of the exchange was consistent with the observations. This control is exerted over the long sill, which restricts access to the fjord. The maximum density at the sill was observed during neap tides. No distinct peaks in the velocity at the sill were observed during the inflows. During each inflow, associated with a neap tide, about 20 percent of the water in the fjord was replaced. These exchanges occurred over periods of 5-10 days. An internal tide was observed in Indian Arm in all three winters studied. In the winter of 1983-84, this internal tide was observed to change from a predominantly M_2 internal response to a predominantly K_1. This change in the response is explained as a partial resonance response of the system. During the 1983-84 winter, the resonance period steadily increased from 14 hours at the start to 22 hours at the end. It is suggested that the enhanced internal response at the K_1 frequency, late in the winter, is due to resonance. Fitting of normal modes was done to look at the energy flux in Indian Arm. About 20-30 percent of the energy flux is found to propagate from the head of the inlet, supporting the resonance hypothesis, which requires energy to be reflected from the head. The energy sinks for the barotropic tide are investigated using a variety of data. From an analysis of the tidal data, it is estimated that a total of 10-15 percent of the barotropic tidal energy which enters Burrard Inlet is dissipated. About 0.7 MW is lost from the barotropic tide in the vicinity of the Indian Arm sill. About 0.3 MW was found in internal waves propagating away from the sill. Of this flux about 60 percent was in the internal tide, with 40 percent in high-frequency internal waves. The vertical diffusion coefficient (K_v) is determined from an analysis of the density data. K_v is found to be related to the buoyancy frequency N by the relationship, $K_v \propto N^{0.86}$. Using K_v and N, the amount of energy which does work against buoyancy is found to be about 100 kW. From this energy estimate, the flux Richardson number (R_f) is estimated be 0.05-0.1.

De Young, B., and Pond, S. 1989. Partition of energy loss from the barotropic tide in fjords. *Journal of Physical Oceanography* 19(2):246-252.

As the barotropic tide propagates into and out of a fjord, it loses energy to friction, internal tides, and high-frequency internal waves. Estimates of these losses for three British Columbia fjords, using current meter data, indicate that friction is negligible in two, but important in one inlet. The length and depth of the sill determine the importance of friction. When friction is not important, most of the energy lost goes into the internal tide but less than half of this energy propagates away from the sill. Simple models of the internal tide predict the correct energy transfer to satisfy an energy budget but do not agree with observations of the internal tidal energy flux away from the sill. Energy loss from the internal tide in or near the generation zone would account for the discrepancy. The energy flux of the high-frequency internal wave field is relatively small, about 2 percent of the energy lost. (18 refs)

Dick, G., and Siedler, G. 1985. Barotropic tides in the northeast Atlantic inferred from moored current meter data. (See complete entry in Section VIII.)

Dick, S. 1987. The tidal currents around the island of Sylt: Numerical investigations of the principal lunar semi-diurnal tide (M_2) (summary) (Gezeitenströmungen um Sylt. Numerische untersuchungen zur halbtägigen hauptmontide (M_2)). (See complete entry in Section VI.)

Dijkzeul, J. C. M. 1984. Tide filters. *Journal of Hydraulic Engineering*, ASCE, 110(7):981-987.

In engineering studies with numerical tide models it is often necessary to isolate the variations of the height of water levels or the intensities of the currents in certain frequency bands. It may be desirable to obtain time series of the diurnal or semidiurnal water level variations of a record free from meteorological disturbances and free from overtides. Such time series can be obtained by digital filtering of the original records. A series of bandpass filters for important tidal frequency bands were designed and results are discussed. In the design the effort was directed to fulfill the following requirements:
(a) The filter should pass information in the chosen tidal frequency band. (b) The modulus of the filter should be very close to unity in the chosen tidal frequency band. (c) The phase of the filter should be zero in the chosen tidal frequency band. (d) Outside the chosen band the modulus of the filter should be close to zero. (e) The band width should be sufficiently wide to permit transmission of all tidal frequencies in the chosen band. (f) The filtered time series should be represented as a time series at the same times as the original time series (thus a time series at the whole hour should, after filtering again, be represented at the whole hour). The application of these filters to model results and field data has proven to be an important tool in engineering studies with numerical models. (4 refs)

DiLorenzo, J. L. 1986. The overtide and filtering response of inlet/bay systems. (See complete entry in Section VI.)

Donnell, B. P., and McAnally, W. H., Jr. 1985. Spectral analysis of Columbia River Estuary currents. Technical Report HL-85-5. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

A spectral analysis study was conducted to determine if wind-induced currents within the Columbia River estuary were sufficiently large to justify their inclusion in a numerical model of sediment transport within the estuary. Completion of the analysis showed that wind-induced current velocities were considerably less than 0.5 fps and consequently have little effect on instantaneous sediment transport. (10 refs)

Dooley, H. D. 1979. Factors influencing water movements in the Firth of Clyde. *Estuarine and Coastal Marine Science* 9(5):631-641.

In the period 1972-1974, 530 days of current observations were obtained in the Firth of Clyde, on the west coast of Scotland. In addition hydrographic surveys were conducted at frequent intervals from which geostrophic currents were calculated. Tidal streams in the area were low (<10 cm s^{-1}); and because of the resulting low levels of turbulence and mixing, the water structure was patchy with relatively large horizontal and vertical density gradients. Many of the fluctuations in velocity were due to advection of the patches which were in geostrophic balance. In addition there were wind-driven flows which occasionally caused rapid renewal of the water in the Firth of Clyde. The wind/current relationship was complex, however, and appeared dependent on the existing density distribution. (7 refs)

Dronkers, J. 1982. Conditions for gradient-type dispersive transport in one-dimensional, tidally averaged transport models. (See complete entry in Section III.)

†**Dunbar, D. C.** 1985. A numerical model of stratified circulation in a shallow-silled inlet. (See complete entry in Section VI.)

Dyer, K. R. 1986. *Coastal and estuarine sediment dynamics*. (See complete entry in Section II.)

†Eades, J. B., Jr. 1978. Tidal frequency estimation for closed basins. AMA Report No. 78-11. Jericho, NY: Analytical Mechanics Association, Inc.

The basic aim in this work was to develop a method for determining the fundamental tidal frequencies for closed basins of water by means of an eigen-value analysis. In this regard, the mathematical model which was to be employed was the so-called Laplace Tidal Equations. The proposed procedure for solving these was to represent a different and somewhat unique approach. It was proposed that these mathematical statements by Laplace would be cast in a format employing the finite element method. Once this model of the governing expressions was in hand, it was proposed that solutions for the tidal frequencies be pursued. (15 refs)

†Eisma, D., Gaast, S. J. van der, Martin, J. M., and Thomas, A. J. 1978. Suspended matter and bottom deposits of the Orinoco Delta: Turbidity, mineralogy and elementary composition. (See complete entry in Section II.)

Elahi, K. Z., and Noor, M. A. 1983. Tidal dynamics of the Pakistani coastal water. (See complete entry in Section VI.)

†Elliott, A. J. 1979. A numerical scheme for predicting the location of tidally-generated fronts in shallow water. (See complete entry in Section VI.)

†El-Sabh, M. I., Murty, T. S., and Briand, J. M. 1984. Storm surges in the St. Lawrence Estuary (Les ondes de tempete dans l'estuaire du Saint-Laurent). *Sciences et Techniques de L'eau* 17(1):15-24 (In French).

Hourly observed and predicted sea level variations in the St. Lawrence Estuary, for a period of 11 years (1965-1975), were examined to describe the storm surge amplitudes. A statistical analysis was used to determine monthly and annual distributions in addition to return periods for positive and negative surges for various amplitudes. Influence of topography, location of a given tide station with reference to storm tracks, freshwater discharge from rivers, the presence of ice cover in winter months, and general meteorological conditions in the area on storm surge amplitudes were examined. The results show that the amplitudes depend on the phase of the tide and they are subject to annual, seasonal, and temporal variations.

†Engel, M. 1976. The simulation of motions in the sea using numerical models: Applications and limitations. (See complete entry in Section VI.)

Essen, H.-H., Freygang, T., Gurgel, K.-W., and Schirmer, F. 1984. Surface currents in front of Sylt--Radar measurements in fall 1983--(Summary). (See complete entry in Section VIII).

Ewertowski, R. 1988. Mathematical model of the River Odra Estuary. (See complete entry in Section VI.)

†Ewing, D. J. F. 1982. The spreading-out of cooling water discharges from direct-cooled power stations. (See complete entry in Section VI.)

Falconer, R. A. 1984. A mathematical model study of the flushing characteristics of a shallow tidal bay. (See complete entry in Section VI.)

Falconer, R. A. 1985. Application of numerical models in the hydraulic design and operation of four U.K. harbours. (See complete entry in Section VI.)

†Falconer, R. A. 1983. Mathematical models for the water industry. (See complete entry in Section VI.)

Falconer, R. A. 1985. Residual currents in Port Talbot Harbour: A mathematical model study. (See complete entry in Section VI.)

Falconer, R. A. 1984. Temperature distributions in tidal flow field. (See complete entry in Section VI.)

Falconer, R. A., and Owens, P. H. 1984. Mathematical modelling of tidal currents in the Humber Estuary. (See complete entry in Section VI.)

Falconer, R. A., Wolanski, E., and Mardapitta-Hadjipandeli, L. 1986. Modeling tidal circulation in an island's wake. (See complete entry in Section VI.)

Fandry, C. B., Hubbert, G. D., and McIntosh, P. C. 1985. Comparison of predictions of a numerical model and observations of tides in Bass Strait. (See complete entry in Section VI.)

Farmer, D. M. 1989. Tide-induced variation of the dynamics of a salt wedge estuary. (See complete entry in Section III.)

Fedosh, M. S., and Munday, J. D., Jr. 1982. Satellite analysis of estuarine plume behavior. (See complete entry in Section VIII.)

†Filadelfo, R. J. 1984. Subtidal sea level and current variability in the Hudson Raritan Estuary. (See complete entry in Section VI.)

†Fisher, C. W. 1986. Tidal circulation in Chesapeake Bay. (See complete entry in Section VI.)

FitzGerald, D. M., and Nummedal, D. 1983. Response characteristics of an ebb-dominated tidal inlet channel. *Journal of Sedimentary Petrology* 53(3):833-845.

A 3-year study (July 1974 to July 1977) of Price Inlet, South Carolina, monitored inlet hydraulics and channel morphology. The inlet is strongly ebb-dominant. Both the peak and mean current velocities during ebb exceed the corresponding velocities during flood. The velocity asymmetry is caused by changes in inlet efficiency during the tidal cycle. The intertidal marsh of the Price Inlet drainage area experiences a change in open-water surface area of about 670 percent during an average tidal cycle. At high tide, the large water surface of the marsh is responsible for inefficient exchange of water through the inlet. This causes a long time lag between ocean and bay tides. The small surface area of open water in the marsh at low tide, on the other hand, yields nearly no time lag. These differential time lags cause longer flood durations than ebb durations in the inlet throat and, consequently, stronger ebb velocities. Monitoring of the cross-sectional flow area of the inlet throat demonstrates rapid adjustment to changing flow conditions. The 1,159-m^2 cross-sectional area of the inlet throat varied as much as 8.3 percent during one tidal cycle. The cross-sectional area varied in phase with the tidal range. Long-term changes in the dimensions of the channel appear to be a direct result of changes in the size of ebb-tidal delta shoals. During the study period, the growth of the linear bars in the channel margin gradually reduced wave energy along the inlet shoreline and on the inner ebb-tidal delta platform. This in turn reduced sediment transport into the inlet, which resulted in a gradual increase in the cross-sectional area of the channel. Seasonal fluctuations in mean sea level appear to have little effect on the inlet channel. (25 refs)

Forbes, A. M. G., and Church, J. A. 1983. Circulation in the Gulf of Carpentaria, II: Residual currents and mean sea level. *Australian Journal of Marine and Freshwater Research* 34(1):11-22.

Recent observations of satellite-tracked drogued buoys in the Gulf of Carpentaria indicate a slow, clockwise mean circulation, which appears to be a permanent feature in the gulf. Residual currents, derived from 3-5 months of recent current meter observations, and from a numerical tidal model of the gulf, are compared with the motions deduced from the buoys. Northwest monsoon winds and density-induced currents enhance the clockwise circulation. However, application of the southeast trade wind stress at neap tides drives a counterclockwise circulation, and at spring tides, a weak clockwise circulation. The large annual variation of mean sea level in the gulf is a maximum in the southeast corner (75 cm): 70 percent of this can be accounted for by the effects of winds, atmospheric pressure, and steric variations, all of which exhibit marked seasonality, are approximately in phase, and are thus additive. (15 refs)

Fornerino, M., and Le Provost, C. 1985. A model for prediction of the tidal currents in the English Channel. (See complete entry in Section VI.)

Forrester, W. D. 1986. Direct inference of tidal constituents. (See complete entry in Section VII.)

Franco, A. S. 1985. Tidal prediction with a small personal computer. (See complete entry in Section VII.)

Franco, A. S., and de Mesquita, A. R. 1986. On the practical use in hydrography of filtered daily values of mean sea level. *The International Hydrographic Review* 63(2):133-141.

It is shown that the mean monthly sea level of a nonpermanent station can be referred to the long-term sea level of a permanent one when tidal stations are influenced by similar meteorological and oceanographical effects. Practical methods are derived: one is based on the direct transference and the other based on the ratio of the variances of the daily mean sea level. Applications of the methods are made for the ports of Cananeia, Ubatuba, Santos, and Ilha Grande on the southern coast of Brazil. (2 refs)

Franco, A. S., and Harari, J. 1988. Tidal analysis of long series. *The International Hydrographic Review* 65(1):141-158.

It is shown how M (≥ 5) sets of Fourier coefficients obtained from M successive Fast Fourier Transforms (FFT) of 2^{14} tapered hourly heights can be combined to obtain the harmonic constants of the clusters of the main astronomical and shallow-water constituents and their respective satellites. It is also shown how the clusters of the shallow-water constituents are formed. (12 refs)

Fromme, G. A. W. 1985. The dynamics of the Keurbooms-Bitou Estuary. CSIR Report T/SEA 8511. Stellenbosch, South Africa: National Research Institute for Oceanology, Council for Scientific and Industrial Research.

Problems with the alleged sanding-up of the Keurbooms Estuary and the apparently continued southwestward migration of the tidal inlet, which threatens to destroy the famous Lookout Beach at Plettenberg Bay, as well as development plans such as extensions of the town and the necessary additional water supply, necessitated a reassessment of the physical conditions of the combined Keurbooms and Bitou estuaries. All available previous studies and cartographic evidence from as far back as 1867 and up to 1980 were used, and a series of surveys and inspections were carried out during 1984. This report covers the hydraulics and coastal dynamics aspects of the system. (19 refs)

Fryer, J. J., and Easton, A. K. 1980. Hydrodynamics of the Gippsland Lakes. In *7th Australasian conference on hydraulics and fluid mechanics,* 18-22 August 1980, Brisbane, Australia, 500-504. Barton, Australia: The Institution of Engineers, Australia.

A narrow man-made entrance connects the estuarine Gippsland Lakes with Bass Strait. This paper describes the response of the system of lakes to the influx of water from the ocean in terms of salinity intrusion, height attenuation, and phase lags. Modifications due to river discharges are quantified from flood conditions, when the lakes are virtually purged of seawater, to droughts, when the sea makes up the net loss of water due to evaporation. Meteorological conditions induce significant resonance, setup, and drawdown in various regions of the lakes. Suggestions are made on methods of regulating the ingress of seawater into Lake Wellington, and conditions in the lakes prior to the construction of the permanent entrance in 1889 are estimated. (8 refs)

Gade, H. G., Edwards, A., and Svendsen, H., ed. 1983. *Coastal oceanography.* NATO Conference Series IV, Vol 11. New York: Plenum Press.

This volume evolved from the Coastal Oceanography Workshop held as a NATO Advanced Research Institute at Os, Norway, 6-11 June 1982. The aims of the workshop were to deal with the frontiers of research on physical oceanography of coastal waters, both inshore and offshore including shelf waters and shelf seas. Contents: On the dynamics of coastal currents, by M. Mork (20 refs); Observations of the Alaska coastal current, by T. C. Royer (16 refs); Aspects of the dynamics of the residual circulation of the Arabian Gulf, by J. R. Hunter (9 refs); Hydrodynamic model of a stratified sea, by N. S. Heaps (6 refs); Three dimensional models of North Sea circulation, by A. M. Davies (21 refs); On the circulation of the stratified North Sea, by J. O. Backhaus (23 refs); The state-of-the-art in coastal ocean modelling: A numerical model of coastal upwelling off Peru - including mixed layer dynamics, by J. J. O'Brien and G. W. Heburn (56 refs); The currents in a shallow coastal corner region - the German Bight - model, measurements and forecast, by E. Mittelstaedt (1 ref); Upwellings and Kelvin waves generated by transient atmospheric fronts, by M. Crépon and C. Richez (9 refs); Wind-forced shelf break upwelling, by B. D. Petrie (8 refs); A seasonal upwelling event observed off the west coast of British Columbia, Canada, by H. J. Freeland (6 refs); Shelf waves of diurnal period along Vancouver Island, by W. R. Crawford, R. E. Thomson and W. S. Huggett (18 refs); Topographic influences on coastal circulation: A review, by G. A. Cannon and G. S. E. Lagerloef (28 refs); Topographically induced variability in the Baltic Sea, by A. Aitsam, J. Elken, L. Talpsepp and J. Laanemets (18 refs); An additional analysis of inertial oscillations on the continental shelf, by C. Millot and C. Moulin (3 refs); Coastal upwelling, cyclogenesis and squid fishing near Cape Farewell, New Zealand, by M. J. Bowman, S. M. Chiswell, P. L. Lapennas, R. A. Murtagh, B. A. Foster, V. Wilkinson and W. Battaerd (37 refs); Whirls in the Norwegian coastal current, by T. A. McClimans and J. H. Nilsen (11 refs); Observations of instabilities of a Great Lakes coastal current, by T. Green (13 refs); Stratified flow over sills, by D. M. Farmer (42 refs); subcritical rotating channel flow across a ridge, by K. Borenäs (4 refs); Internal gravity waves in sill fjords: Vertical modes, ray theory and comparison with observations, by B. Cushman-Roisin and

H. Svendsen (16 refs); Numerical simulations of internal wave generation in sill fjords, by G. Mørk and B. Gjevik (8 refs); Two-year observations of coastal-fjord interactions in the Strait of Juan de Fuca, by J. R. Holbrook, G. A. Cannon and D. G. Kachel (19 refs); Water exchange between the sea and complicated fjords with special reference to the Baltic water exchange, by A. Stigebrandt (6 refs); Shelf-fjord exchange on the west coast of Vancouver Island, by D. J. Stucchi (10 refs); Considerations of coastally forced flow in a branched fjord, by J. M. Klinck, B. Cushman-Roisin and J. J. O'Brien (8 refs); Some aspects of circulation along the Alaskan Beaufort Sea coast, by J. B. Matthews (42 refs); Low frequency fluctuations in the Skagerrak, by G. Shaffer (23 refs); Reduced gravity modelling of outer Oslofjorden, by S. A. Gjerp (8 refs); On entrainment in two-layer stratified flow - with special focus on an arctic sill-fjord, by Fl. Bo Pederson (19 refs); Salt entrainment and mixing processes in an under-ice river plume, by R. G. Ingram (12 refs); On entrainment observed in laboratory and field experiments, by E. Buch (15 refs).

†**Gardner, G. B.** 1984. Internal hydraulics and mixing in highly stratified estuaries. (See complete entry in Section III.)

Garvine, R. W. 1987. Estuary plumes and fronts in shelf waters: A layer model. *Journal of Physical Oceanography* 17(11):1877-1896.

A layer model that treats fronts as discontinuities is developed to study the steady-state behavior of shallow estuary plumes on the continental shelf. The complete range of earth rotation effect is evaluated from small-scale or nonrotating plumes (Kelvin number equal zero). Supercritical flow is assumed in the outlet channel and the method of characteristics is used to compute the flow downstream. Nonrotating plumes have strong boundary fronts and concentrate their greatest layer depth and mass transport offshore near the front, but form no coastal current. Rotating plumes have boundary fronts that weaken soon after discharge, form a turning region where Coriolis action deflects the flow toward shore, and subsequently set up a coastal current. Soon after its formation this coastal current is bounded offshore by a strong front called the coastal front, across which the momentum balance changes from nearly inertial in the turning region upstream to nearly geostrophic in the coastal current itself. In traversing this front the flow loses total energy, but gains potential vorticity. Farther downstream the coastal front weakens, and meanders of the coastal current begin. Their wavelengths are short, about two Rossby radii, and their amplitudes grow, doubling after about 20 Rossby radii. The presence of supercritical speeds and fronts generates a plume dynamics that is remote from any linear description but shows analogous behavior to supersonic, compressible gas flow with shock waves. (31 refs)

Gascoine, I. S., and Jury, K. M. 1984. The development and use of a theoretical mathematical model for the Medway Estuary. (See complete entry in Section VI.)

Gerritsen, F. 1985. Tidal hydraulics - Historic perspective and future trends in engineering analysis. In *1985 Australasian conference on coastal and ocean engineering,* 2-6 December 1985, Christchurch, New Zealand, 1:1-28. Barton, A.C.T., Australia: The Institution of Engineers, Australia.

In this paper the role of tidal hydraulics and its relationship to coastal engineering practice are examined. The mathematical formulations of the tidal hydraulics problems are presented and the various solutions examined, whereby the one- and two-dimensional (depth-averaged) forms of the equations are particularly considered. Of the one-dimensional tidal equations both analytical and numerical solutions have been developed. For the two-dimensional forms of the equations only numerical solutions offer a practical way for real problem solving, particularly if the equations include the surface wind stress as an added term. This is also true for the three-dimensional equations where the vertical velocity distribution of the horizontal velocities and the vertical velocity components are considered. The two-layered and multilayered systems have promise and are possible because of the high capacity of modern computers. In addition to the tidal equations per se, various formulations for the distribution of salt, heat, and other dissolved matter are discussed. The tidal equations are then coupled to diffusion equations to calculate the distribution of suspended or dissolved matter. This approach is valuable for an evaluation of the ecological impact of future engineering works. Of significant interest is the problem area in which the channel bottom consists of a movable bed, subject to changes due to the tidal currents. The study of the behavior of natural channels affected by the acts of men, e.g., by dredging, falls in this category, as well as the stability of tidal inlets. For a complete solution of this problem the hydraulic equations have to be coupled with a set of equations describing the motion of sediment and the changes in the water depth due to sedimentation or erosion. At present,

semiempirical solutions are utilized for these problems, because of the lack of a reliable formulation for the description of sediment transport in tidal flow. More research of fundamental nature is required to fill this gap in knowledge. For the stability problem in estuaries and tidal inlets an overview is given of the present state of the art. (52 refs)

Godin, G. 1984. A comparison between two simultaneous sets of current measurements in the Strait of Juan de Fuca. (See complete entry in Section VIII.)

†**Godin, G.** 1980. Cotidal charts for Canada. (See complete entry in Section VIII.)

Godin, G. 1986. The use of nodal corrections in the calculation of harmonic constants. (See complete entry in Section VIII.)

Goh, H. S., Rajendra, A. S., and Pui, S. K. 1983. Coastal problems encountered at Muara Port area in Brunei. In *International conference on coastal and port engineering in developing countries,* 20-26 March 1983, Colombo, Sri Lanka, I:115-129. Colombo, Sri Lanka: Conventions (Colombo) Ltd.

This paper discusses the winds, tides, tidal currents, waves, and swell at Muara Port, Brunei. It also discusses the morphological changes with emphasis on the coastal problems encountered since construction of an approach channel through Pelompong Spit in 1969. Erosion, scouring, stability of a training bund, shoaling, and siltation are described and the associated protection measures outlined. (2 refs)

†**Goodrich, D. M.** 1985. On stratification and wind-induced mixing in the Chesapeake Bay. (See complete entry in Section III.)

Gotlib, V. Y., and Kagan, B. A. 1985. A reconstruction of the tides in the paleocean: Results of a numerical simulation. *Deutsche Hydrographische Zeitschrift* 38(2):43-67.

Results of a calculation of the spectrum of eigenoscillations, spatial structure, and energy characteristics of the M_2 tidal wave in the paleocean for nine periods of the Phanerozoic are discussed. It has been shown that consolidation of the continents causes attenuation of the semidiurnal and amplification of the diurnal eigenoscillations, and vice versa, isolation of the continents contributes to amplification of the semidiurnal oscillations and attenuation of the diurnal ones. Changes in the resonant properties of the world ocean result in a reconstruction of spatial structure of the tides and in evolution of the tidal energy dissipation. As it retreats to the past, the tidal energy dissipation first decreases and then, beginning from the period between the Late Carboniferous-Early Permian, increases, reaching its maximum in the Early Cambrian. (27 refs)

Graham, D. S., and Mehta, A. J. 1981. Burial design criteria for tidal flow crossings. (See complete entry in Section VI.)

Granat, M. A., Brogdon, N. J., Cartwright, J. T., and McAnally, W. H., Jr. 1989. Verification of the hydrodynamic and sediment transport hybrid modeling system for Cumberland Sound and Kings Bay navigation channel, Georgia. (See complete entry in Section VI.)

Granat, M. A., Gulbrandsen, L. F., and Pankow, V. R. 1985. Reverification of the Chesapeake Bay model; Cheseapeake Bay hydraulic model investigation. Technical Report HL-85-3. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

The Chesapeake Bay hydraulic model, an 8.6-acre fixed-bed model, constructed to a horizontal scale ratio of 1:1000 and a vertical ratio of 1:100, reproduces the entire Chesapeake Bay estuarine system from the offshore Atlantic Ocean to the head of tide for all tributaries. The model is equipped with the necessary appurtenances to accurately reproduce and measure tidal heights, tidal currents, salinity distributions, and freshwater inflows. It is the largest and one of the most sophisticated estuarine models of its kind. State-of-the-art modeling techniques continue to be developed and incorporated into the complex model operating system. Complete computer control and data acquisition capabilities ensure accurate and precise monitoring and control throughout the 14-acre shelter. Dynamic testing conditions associated with time-varying freshwater hydrographic conditions and lunar-monthly tidal reproduction are important technological advances utilized at the model. During the summer of 1980, unusual concrete expansion on the model resulted in compression and unequal vertical concrete movement. Damaged areas were remolded and all existing and new expansion joints were widened and filled with a closed cell expansion material. Reverification of the model was required following this rehabilitation effort. This report provides all the necessary information to adequately assess model reverification and model operating capabilities. The nonsynoptic nature and short durations of prototype data greatly complicate the verification process. Model and prototype hydrodynamic

characteristics are compared in a manner that clarifies model and prototype response trends while minimizing the amount of noise associated with complex and dynamic prototype conditions. Tide and velocity characteristics are examined under "quasi-steady-state" conditions associated with the reproduction of a repetitive M_2 cosine tide and a constant, long-term average freshwater discharge and distribution. Salinity characteristics are examined under more dynamic conditions associated with the reproduction of a 12-tidal constituent, 56-cycle tide; and a time-varying 4-year freshwater inflow hydrograph simulating the prototype weekly average discharge and distribution. An induced-mixing bubbler system is used to enhance vertical mixing to more accurately reflect prototype salinity structure resulting from wind-associated energy. Simplifications and associated limitations of model boundary conditions used in simulating dynamic prototype conditions are discussed. Direct extrapolation of model results to the prototype should be undertaken with these considerations in mind. When evaluated in such a manner, excellent model reproductions of general prototype tide, velocity, and salinity characteristics are demonstrated. The Chesapeake Bay hydraulic model is shown to be a valuable tool for assessing man-induced changes to the three-dimensional hydrodynamic characteristics of the Chesapeake Bay estuarine system. (19 refs)

Gray, W. G., and Kinnmark, I. P. E. 1983. QUIET: A reduced noise finite element model for tidal circulation. (See complete entry in Section VI.)

Green, T. 1986. The double-diffusive aspects of sedimentation. (See complete entry in Section II.)

Griffin, D. A., Middleton, J. H., and Bode, L. 1987. The tidal and longer-period circulation of Capricornia, southern Great Barrier Reef. *Australian Journal of Marine and Freshwater Research* 38(4):461-474.

Between June and December 1983, nine current meters and three water level recorders were deployed on the continental shelf and slope of the Capricornia Section of the Great Barrier Reef between Fraser Island (25°S) and the mouth of the Capricorn Channel (23°S) on the east coast of Australia. Tidal analyses of the hourly data set reveal an amplification of the semidiurnal tides as they propagate northwestward into the Capricorn Channel. The results of a numerical model of tidal flow show excellent agreement with observations. The daily averaged (nontidal) currents are highly variable and produce complex circulation patterns, but with a mean flow generally alongshore to the northwest. Comparisons with previous drifter studies and satellite-tracked buoy data suggest that the southeastward flowing East Australian Current drives a large clockwise eddy, in the lee of the Swain Reefs, located east of the study region. It is postulated that this eddy, in addition to the generally northwestward wind stress, contributes to the northwestward flow within the study region. Temperatures recorded by the deployed instruments and temperature profiles from conductivity-temperature-depth casts confirm that tidal and longer period variability contribute to upwelling onto the continental shelf. (17 refs)

†**Gross, T. F.** 1984. Tidal time dependence of geophysical turbulent boundary layers. Ph.D. diss., University of Washington, Seattle.

Measurements of the mean velocity and stress profiles obtained in a simple horizontally uniform, unstratified tidal flow and in a steady canal flow demonstrate the expected scaling of the turbulent bottom boundary layer. Within the uncertainties imposed upon the measurements by natural turbulence variance and nonstationarity of the means, 10-minute averages of velocities and stress in the tidal flow give agreement to the quasi-stationary logarithmic velocity profile boundary layer theory ($u_* \pm 8.8\%$, $Z_0 \pm 50\%$, $u'w' \pm 40\%$). The stationary canal flow demonstrates the same agreement and clearly demonstrates the linear stress profile expected in depth-limited flows. By using longer averaging times the errors of the canal data were less ($u_* \pm 7.0\%$, $Z_0 \pm 40\%$, $u'w' \pm 18\%$$). Simple scaling of the time-dependent momentum equation indicates that acceleration and advection should be large contributors to the stress divergence-pressure gradient balance. The effects of this dependence were modeled using the turbulent kinetic energy equation second-order closure. The model, which was forced with a tidal time-varying pressure gradient, solves for velocity and stress profiles through the tidal period. It was found that for the parameters of Skagit Bay the development of the stress profile was fast enough that the quasi-steady model solution holds throughout most of the tidal period. Spectral analysis reveals that the high-frequency isotropic inertial range scales with u_* and distance to the wall. Estimates of dissipation from spectra give u_* to ± 10 percent. The low-frequency contribution to the Reynolds stress was found to be contained in relatively rare episodic events of short duration. These events are described in the steady canal flow by conditional sampling and Lagrangian correlations. Their initial size, strength

and rate of dissipation are well modeled by simple scaling by depth, the boundary shear velocity, and the spectral rate of energy dissipation.

Guymer, I., and West, J. R. 1988. The determination of estuarine diffusion coefficients using a fluorimetric dye tracing technique. (See complete entry in Section VIII.)

Hamilton, K. 1984. Detection of the lunar diurnal atmospheric tide. *Monthly Weather Review* 112(8):1620-1625.

A search was conducted for the principal lunar diurnal tide (0_1) in an 18-1/2-year time series of twice-daily digitized sea level pressure analyses covering the region 20-90° N. At 20, 25, 30, and possibly at 35° N there is evidence for a systematic variation of the zonal wave number one harmonic of the pressure as a function of the phase of the 0_1 tidal potential. This variation is clearly dominated by a westward traveling component (i.e., one that follows the tidal potential around the earth each day). The computed amplitudes are very small (less than 0.01 mb), and north of 35° N the random meteorological noise obscures the 0_1 tidal oscillation to the point where it cannot be detected from analysis of the present data. (10 refs)

Hamm, L., Quetin, B., and Usseglio-Polatera, J. M. 1985. Two-dimensional modelling of wind-induced currents in coastal and harbour area. (See complete entry in Section VI.)

Hamon, B. V. 1988. Spurious long-period tides due to tide gauge errors. (See complete entry in Section VII.)

Hao-lin, L., and You-fa, X. 1983. A finite-element method for numerical computation of unsteady flow in estuarine branchine channels. (See complete entry in Section VIII.)

Harris, J. E., Hinwood, J. B., Marsden, M. A. H., and Sternberg, R. W. 1979. Water movements, sediment transport and deposition, Western Port, Victoria. (See complete entry in Section II.)

Harris, P. T., and Collins, M. 1988. Estimation of annual bedload flux in a macrotidal estuary: Bristol Channel, U.K. (See complete entry in Section VIII.)

Hayes, M. O. 1983. Role of geomorphological processes in inlet and port-entrance sedimentation problems: An overview. (See complete entry in Section II.)

†**Hayward, D. M.** 1986. Contribution to the hydrobiology of the York River: Predicting surface mixed layer depth. (See complete entry in Section III.)

Healy, T., Black, K., and de Lange, W. P. 1985. Numerical model field requirements for detailed simulation of currents and sediment transport in large tidal-inlet harbours. (See complete entry in Section VI.)

Hearn, C. J. 1985. On the value of the mixing efficiency in the Simpson-Hunter h/u^3 criterion. *Deutsche Hydrographische Zeitschrift* 38(3):133-145.

The Simpson-Hunter h/u^3 criterion involves a tidal mixing efficiency ϵ which determines the location of seasonal thermal fronts in shelf seas. Fronts observed on continental tidal shelves throughout the world all give similar empirical values of $\epsilon \approx 3 \times 10^{-3}$. This suggests that ϵ is an intrinsic parameter of tidal mixing processes. However, no theoretical estimate of ϵ has yet been reported, and so a simple steady-state theory for ϵ is developed in this paper. The theoretical ϵ,.calculated using a logarithmic velocity profile, agrees well with the empirical value. A detailed comparison is made between the theory and data for the Celtic Sea front. (19 refs).

Hearn, C. J., and Pearce, A. F. 1985. NOAA satellite and airborne sensing of a small-scale, coastal tidal jet. *Australian Journal of Marine and Freshwater Research* 36(5):643-653.

Koombana Bay, on the southwest coast of Australia, contains a tidal jet that emanates from Leschenault Inlet via a man-made channel 150 m wide. The tides are of mixed diurnal-semidiurnal character. The strongest jets are induced by the diurnal tide and flow at night in summer and during daytime in winter. The duration of the discharge is about 9 hr, after which the maximum length of the jet is a few kilometres. Extensive field studies together with numerical and analytical modelling have recently been completed on the jet. These allowed predictions of optimum times for viewing the jet via an airborne thermal scanner aboard the CSIRO Fokker F27 aircraft, and a NOAA7 satellite image. The airborne imager mapped the late-summer jet, which consisted of night-cooled water from the shallow inlet. Because the satellite pass occurs in late afternoon, the seasonality of the tide limits visibility of

the jet in the imagery to late winter. The NOAA7 image shows a jet composed of warm water that has been heated during the day inside the inlet. These observations confirm the sea data and model results and are believed to be the first use of NOAA imagery to resolve a coastal oceanographic feature of this scale. (13 refs).

Hearn, C. J., Hunter, J. R., Imberger, J., and van Senden, D. 1985. Tidally induced jet in Koombana Bay, Western Australia. (See complete entry in Section VI.)

Heath, R. A. 1981. Estimates of the resonant period and *Q* in the semi-diurnal tidal band in the North Atlantic and Pacific oceans. *Deep-Sea Research* 28A(5):481-493.

Fitting the deep-sea harmonic tidal constants to a single normal development of the North Atlantic semidiurnal tides gives estimates of the resonant period based on the vector-averaged data of between 12.6 and 12.8 hours in the semidiurnal tidal band with a Q of between 10 and 12. A two-mode development has been used in the Pacific Ocean. The percentage frequency separation between the modes has been calculated from the travel time of a Kelvin wave around the perimeter. A relationship between the resonant period and Q has been derived; it depends on the observed spatial separation of the open-ocean amplitude maxima of the M_2, S_2, and N_2 tidal constituents evident in the tidal charts of the western Pacific. The ratio of the maximum open-ocean amplitude of the M_2 and S_2 tide was then used to estimate the relative coupling between the tidal potential and the two modes as a function of the resonant period. The two relationships are then used in calculating the frequency-dependent change in phase with position to allow comparison with the estimate made from the tidal charts. The resonant periods near the semidiurnal tidal band in the Pacific are estimated to be at 10.2 and 12.8 hours with a Q, which has been assumed in the analysis to be the same for both modes, of about 5. (14 refs).

Heath, R. A. 1981. Resonant period and *Q* of the Celtic Sea and Bristol Channel. (See complete entry in Section VI.)

Heath, R. A. 1983. Tidal currents in the southwestern Pacific Basin and Campbell Plateau, southeast of New Zealand. (See complete entry in Section VIII.)

Heath, R. A. 1981. Variations of the semi-diurnal tidal admittance near New Zealand. *Deep-Sea Research* 28A(8):847-858.

A sharp decrease in the semidiurnal tidal admittances around New Zealand occurs for constituents with periods less than 12.19 hours. The situation is epitomized here by analysis of the principal lunar (M_2) and solar (S_2) constituents, the admittance of S_2 being significantly smaller than that of M_2. Incident tidal energy from the northeast of New Zealand gives rise to trapped progressive wave components moving anticlockwise around the coast, whereas incident tidal energy from the northwest gives rise to standing wave components on the west coast. Differences in the relative strength of the tidal energy incident on New Zealand from different directions result initially from spatial differences in the tidal distribution of the semidiurnal constituents in the Pacific Ocean further north. The M_2 tide has a dominant trapped progressive wave component around New Zealand whereas on the west coast the S_2 standing wave component is slightly larger than the small progressive wave component. Little of the standing wave component energy on the west coast is transmitted around southern New Zealand to the east coast, and this leads to the observed decrease in the S_2 tidal admittance from the west to the east coast. (16 Refs)

Heathershaw, A. D., and Langhorne, D. N. 1988. Observations of near-bed velocity profiles and seabed roughness in tidal currents flowing over sandy gravels. *Estuarine, Coastal and Shelf Science* 26(5):459-482.

Measurements of near-bed velocity profiles and bottom roughness in tidal currents flowing over sandy gravels in the west Solent, England, have shown that, although the seabed in the immediate vicinity of the study area was generally level and devoid of regular bed form, the observed velocity profiles were consistently curved concave downwards. This behavior may be attributed to the presence of an internal boundary layer which was due to form drag on irregular topography upstream of the measurement position. Loosely packed gravels of the type found in the West Solent had a geometric mean roughness length of about 0.3 cm. Comparison of the observed ratio of roughness length of mean particle size with laboratory data suggests an equivalent two-dimensional roughness element spacing of about three particle diameters. In contrast to tidal flows over rippled sand beds, the roughness lengths for sandy

gravels remained relatively constant throughout the tidal cycle. Furthermore, these measurements provided no systematic evidence of the effects of flow acceleration on profile-derived estimates of the friction velocity u_* and the roughness length z_0. (39 refs)

†**Heinecken, T. J. E., Bickerton, I. B., Morant, P. D., Heydorn, A. E. F., and Grindley, J. R., ed.** 1982. Estuaries of the Cape; Part 2: Synopses of available information on individual systems; Report 12: Buffels (WES) (CSW 1), Elsies (CSW 2), Sir Lowry's Pass (CSW 8), Steenbras (CSW 9), and Buffels (00S) (CSW 11). Stellenbosch, South Africa: National Research Institute for Oceanology.

Information is summarized on various aspects of the estuaries in the Buffels, Elsies, Sir Lowry's pass, and Steenbras regions of the Cape area of the Republic of South Africa. Rivers, water pollution, erosion, plants and animals are among the topics discussed.

†**Heinecken, T. J. E., comp., Heydorn, A. E. F., and Grindley, J. R., ed.** 1982. Estuaries of the Cape; Part 2: Synopses of available information on individual systems; Report 13: Silvermine (CSW 3). Stellenbosch, South Africa: National Research Institute of Oceanology.

The estuaries of the Cape of Good Hope and their individual systems are described. The function of estuarine systems under variable conditions prevalent along the South African coastline was investigated. Long-term research on selected estuarine systems is described. Topics described include historical background, location, abiotic characteristics, and biological characteristics.

Herbertson, P. W. 1982. Salinity and resource development problems in East Kent. (See complete entry in Section III.)

Hinwood, J. B., and Jones, J. C. E. 1979. Hydrodynamic data for Western Port, Victoria. (See complete entry in Section VIII.)

†**Hires, R. I., Oey, L.-Y., and Mellor, G. L.** 1983. Prediction of oil spill trajectories in New York Harbor. (See complete entry in Section IV.)

Ho, F. P., and Miller, J. F. 1982. Pertinent meteorological and hurricane tide data for Hurricane Carla. (See complete entry in Section VIII.)

Holloway, P. E. 1984. On the semidiurnal internal tide at a shelf-break region on the Australian North West Shelf. (See complete entry in Section VIII.)

Holloway, P. E. 1985. A comparison of semidiurnal internal tides from different bathymetric locations on the Australian North West Shelf. (See complete entry in Section VIII.)

Holly, F. M., Jr., and Usseglio-Poletera, J.-M. 1984. Dispersion simulation in two-dimensional tidal flow. (See complete entry in Section IV.)

Houston, J. R., Vemulakonda, S. R., Scheffner, N. W., and Ebersole, B. A. 1986. Coastal and inlet processes (CIP) numerical modeling system. (See complete entry in Section VI.)

Howarth, M. J. 1981. Intercomparison of AMF VACM and Aanderaa current meters moored in fast tidal currents. (See complete entry in Section VII.)

Howe, B. M., and Munk, W. H. 1988. Deep-sea moorings in a tidal current. *Deep-Sea Research* 35(1):111-119.

A taut mooring has been observed to experience two types of response to tidal forcing. Along the axis of maximum tidal current, the mooring displacement is roughly in phase with the tidal velocity; along the minor tidal axis the mooring displacement lags the tidal velocity by roughly 90 deg, and thus is more nearly in phase with the tidal displacement. For a highly idealized model, the mooring response can be written as a function of two parameters: a dimensionless frequency σ and a dimensionless tidal displacement amplitude α (hence velocity amplitude $\sigma\alpha$). The velocity response occurs for $\sigma^2\alpha \ll 1$ and the displacement response for $\sigma^2\alpha \gg 1$, contrary to observations. The mooring response can be reconciled with the observations by superposing a mean flow, which is more rapid than the tidal flow and is roughly in the direction of the minor tidal axis. (2 refs)

Huang, Z., Yuan, X., Chen, S., and Qin, H. 1986. The experimental investigation for the improvement of Modaomen Outlet of the Pearly River Estuary in China. (See complete entry in Section VI.)

Hunkins, K. 1986. Anomalous diurnal tidal currents on the Yermak Plateau. (See complete entry in Section VIII.)

Huizinga, P. 1984. Application of the Nrio 1-D

hydrodynamic model to the Swartkops Estuary. (See complete entry in Section VI.)

Huthnance, J. M. 1981. Large tidal currents near Bear Island and related tidal energy losses from the North Atlantic. (See complete entry in Section VIII.)

Huthnance, J. M. 1983. Simple models for Atlantic diurnal tides. (See complete entry in Section VI.)

Huzzey, L. M. 1988. The lateral density distribution in a partially mixed estuary. *Estuarine, Coastal and Shelf Science* 26(4):351-358.

The density distribution across the York River is characterized by distinct inhomogeneities, especially in the upper 2 m of the water column. The pattern of variability is repetitive and closely correlated with the semidiurnal tidal cycle and water depth. In the shallow areas the water column remains vertically well-mixed at all times. The density differences are greatest at times of minimum currents. At slack-before-flood, the least dense water is located in a lens over the main channel. Toward the end of the flood cycle, and at slack-before-ebb, this is reversed with the least dense water situated over the shoals. These density differences result in horizontal pressure gradients which at times may be of sufficient strength to generate localized lateral circulations. Such circulation patterns would form zones of convergence or divergence across the estuary depending on the particular density distribution. (13 refs)

†**Huzzey, L. M.** 1986. Lateral variability in a coastal plain estuary. Ph.D. diss., College of William and Mary, Williamsburg, VA.

A series of observations of the density distribution across the York River estuary documents distinct lateral differences in density and degree of vertical mixing. The magnitude of the density differences varies throughout the tidal cycle; maximum lateral gradients occur at times of minimum current. When the density distribution is sufficiently inhomogeneous, longitudinal estuarine fronts are generated. These fronts are axially aligned, up to several miles in length, and are apparent for less than 2 hours at any given location. Although the density difference across the frontal boundary is often small, horizontal pressure gradients acting over a broad frontal region generate the convergent circulations necessary to maintain these fronts. Measurements of the longitudinal velocities across the same section reveal negligible phase difference but a significant amplitude difference between the currents in the channel and those over the shoals. Differential advection across the estuary due to this velocity shear is the process by which the observed density distribution is generated.

Imberger, J., Berman, T., Christian, R. R., Sherr, E. B., Whitney, D. E., Pomeroy, L. R., Wiegert, R. G., and Wiebe, W. J. 1983. The influence of water motion on the distribution and transport of materials in a salt marsh estuary. (See complete entry in Section VI.)

Ingram, R. G. 1983. Vertical mixing at the head of the Laurentian Channel. *Estuarine, Coastal and Shelf Science* 16(3):333-338.

Temperature, salinity, and velocity profiles taken over a 5-day period in the St. Lawrence Estuary at the head of the Laurentian Channel are used to describe the semidiurnal tidal period isopycnal oscillations occurring in this region. The observed variation in the degree of vertical mixing over the tidal cycle is used to support the concept of nutrification of the estuarine surface waters and suggests an explanation for the quarter-diurnal variability of primary production in this region. (13 refs)

Isaji, T., and Spaulding, M. L. 1987. A numerical model of the M_2 and K_1 tide in the northwestern Gulf of Alaska. (See complete entry in Section VI.)

Jarvis, R. M. 1985. Problem associated with the development of a partially open tidal estuary with particular reference to Currimundi Creek, Queensland. (See complete entry in Section V.)

†**Jay, D. A.** 1987. Residual circulation in shallow, stratified estuaries. Ph.D. diss., University of Washington, Seattle.

Residual flows in shallow, stratified estuaries arise primarily from the interaction of the density field, riverflow, and the tidal currents. This study defines three basic types of residual circulation that occur in shallow estuaries and relates each first, to the predominant vertical exchange mechanism causing the mixing of salt and fresh water, and then ultimately to external parameters--the tides, riverflow, and baroclinic forcing. The vehicle for this analysis is an examination of residual flow in the Columbia River estuary, a large, shallow, river estuary, in which the density field alternates regularly between the weakly stratified and highly stratified states. To investigate residual flow generation in and transition mechanisms between these two regimes, scale analyses and

perturbation expansions have been developed of the governing equations for these two conditions. The resulting models successfully predict tidal and residual density and velocity fields and the tidal ranges at which neap-spring and spring-neap transitions occur. The advance and retreat of the saltwater mass in a highly stratified estuary is internal wave-like. Kelvin-Helmholtz instabilities at the interface are the major vertical exchange mechanism. The residual circulation originates primarily from ebb-flood asymmetries in interface thickness and position. The neap-spring transition occurs when the two-layer system is destroyed on flood by internal mixing. In contrast, tidal-frequency, internal oscillations are impossible in the weakly stratified case. Bottom boundary-induced turbulence is the major vertical exchange mechanism, and tidal processes maintain the density field. The spring-neap transition occurs when the gradient Richardson number increases as the tidal range decreases, and this turbulence cannot penetrate into the flow. Stratification increases until a two-layer flow is reestablished. The circulation theory developed here also leads to a new classification system for shallow estuaries. This classification system offers a useful alternative to that of Hansen and Rattray in that classification is based on the strength of the barotropic and baroclinic nonlinearities that drive the residual flow. It indicates the existence of a third regime, the partially mixed state, in which the stratification is strong enough to extinguish turbulence, but too weak for tidal-frequency internal waves to be possible. Vertical exchange is caused primarily by random interaction and consequent breaking of internal waves. Baroclinic mean shear dominates the salt balance. This state is not normally observed in the Columbia River estuary, because the riverflow is too large.

Jiaju, L., and Jingchaeo, Z. 1983. Siltation study of some extension projects of the Lianyun Harbour. (See complete entry in Section II.)

Jiang, J. X., and Falconer, R. A. 1985. The influence of entrance conditions and longshore currents on tidal flushing and circulation in model rectangular harbours. (See complete entry in Section VI.)

†Josanto, V., and Sarma, R. V. 1985. Coastal circulation off Bombay in relation to waste water disposal. (See complete entry in Section IV.)

Joshi, M. 1986. Tide guide. (See complete entry in Section VIII.)

Kalkwijk, J. P. T. 1985. Dispersion of matter at sea under homogeneous conditions. *Deutsche Hydrographische Zeitschrift* 38(6):245-260.

In this paper the dispersion of a solute at sea is examined by means of a horizontal two-dimensional approach. The velocity field is horizontally homogeneous and is characterized by a velocity ellipse with axes of arbitrary magnitude. Stratification is absent. Because of the tidal motion, the dispersion tensor is time dependent. In the case of instantaneous release of a solute, an analytical solution for its spreading is derived. It is particularly shown that the initial behavior of the concentration is very variable and depends on the moment of release and on the dispersion transverse to the mean velocity. The "Breeveertien" experiment (North Sea) is analyzed in terms of the theory presented. In an appendix, estimates for dispersion coefficients under homogeneous conditions are derived. (13 refs)

Kang, Y. Q. 1984. An analytic model of tidal waves in the Yellow Sea. (See complete entry in Section VI.)

Kawahara, M., Hirano, H., Tsubota, T., and Inagaki, K. 1982. Selective lumping finite element method for shallow water flow. (See complete entry in Section VI.)

Kelly, L. R., and Andrews, J. C. 1985. Numerical models for planning coastal circulation studies. (See complete entry in Section VI.)

Kennedy, V. S., ed. 1984. *The estuary as a filter.* (See complete entry in Section VI.)

Kenyon, N. H. 1970. Sand ribbons of European tidal seas. (See complete entry in Section II.)

Kerchaert, P., Roovers, P. P. L., Noordam, A., and De Candt, P. 1986. Artificial beach nourishment on Belgian East Coast. (See complete entry in Section II.)

†Kessler, T. A. 1986. Mixing-primary production coupling in Holberg Inlet, a tidally energetic fjord. (See complete entry in Section VI.)

Ketchum, B. H., ed. 1983. *Esocystems of the world 26: Estuaries and enclosed seas*. New York: Elsevier.

Section I consists of seven chapters which discuss estuarine characteristics, physics of estuarine circulation, responses to estuarine stress, the phytoplankton of estuaries, the zooplankton of estuaries, estuarine benthos, and estuarine fishes. The characteristics of ten enclosed seas are discussed in Section II. Each of these enclosed seas is connected with the open ocean in a way which modifies and controls the circulation within the sea and produces an environment and an ecosystem which are unique and different from the adjacent coastal waters. For several of the enclosed seas there is only a single connection which is narrow and shallow; these are the Mediterranean-type seas. For others there are multiple connections separated by islands or island arcs. (1,741 refs)

Keulegan, G. H. 1989. Estuary numbers. (See complete entry in Section III.)

Kjerfve, B. 1978. Bathymetry as an indicator of net circulation in well mixed estuaries. *Limnology and Oceanography* 23(4):816-821.

In well-mixed, high-salinity estuaries of the southeastern United States, the net circulation is mirrored in the bathymetry. Measurements in North Inlet, South Carolina, indicated a net current reversal across the estuary. The cross-section bathymetry is usually bimodal, with two channels separated by a shallow area. The deeper channel experiences ebb-directed net flow with ebb-oriented sand waves as the predominant bed form. In the shallower channel, the net current is flood-directed. In well-mixed estuaries similar to North Inlet, it may be possible to determine qualitative circulation features from a few lateral and longitudinal bathymetric traces without measurements of current velocity and salinity. (13 refs)

Koblinsky, C. J. 1981. The M_2 tide on the West Florida Shelf. (See complete entry in Section VIII.)

†**Koop, K., comp., Heydorn, A. E. F., and Grindley, J. R., ed.** 1982. Estuaries of the Cape; Part 2: Synopses of available information on individual systems; Report No. 18: Bot/Kleinmond System (CSW 13). Stellenbosch, South Africa: National Research Institute for Oceanology.

A catalog of available information on the Botriviervlei and Kleinmond estuaries of South Africa is presented. Information includes geographic and water flow patterns, physicochemical characteristics, and land use as well as records on flora and fauna of the region.

Koutitas, C. G. 1986. Coastal circulation and sediment transport. (See complete entry in Section II.)

Koutitonsky, V. G., and El-Sabh, M. I. 1985. Estuarine mean flow estimation revisited: Application to the St. Lawrence Estuary. *Journal of Marine Research* 43(1):1-12.

Mean value estimate errors for estuarine (and oceanic) parameters which exhibit serial correlation and nonstationarity over a finite record length are discussed. It is shown that when trends are nonlinear over the record length, the mean value estimate error does not decrease with time. Instead, it goes through a minimum and then increases again. An optimal averaging time over which the mean estimate error is minimum is presented. The mean circulation in the lower St. Lawrence Estuary is described over a record length of 78.5 days in 1979. Standard, bias, and root mean square errors in mean value estimates are discussed, and an averaging time yielding a minimum error is suggested for the lower St. Lawrence Estuary. New measured features of the mean circulation are a coastal current flowing downstream near the north shear which deflects to the right at the mouth, and a 2-cm/s inflow in the bottom layer at midchannel location. (17 refs)

†**Kowalik, Z.** 1981. A study of the M_2 tide in the ice-covered Arctic Ocean. (See complete entry in Section VI.)

Ku, L.-F. 1985. Modulation factors in tidal prediction. *The International Hydrographic Review* 62(2):173-177.

The predicted tide $h(t)$ is usually expressed by the following equation:

$$h(t) = \sum_k A_k f_k(t) \cos (w_k t + u_k (t) - g_k)$$

where w_k, A_k, and g_k are the angular frequency, the amplitude, and phase of the k^{th} constituent, and $f_k(t)$ and $u_k(t)$ are the modulation factors produced by its satellites. For most of the constituents, the most significant period in the modulation factor is 18.6 years which is the period of revolution of the moon's node. For a few constituents like L_2 the most important period is 4.4 years, which is half of the period of the revolution of perigee of the lunar orbit. Because of the slow change in the modulation factors, they are usually assumed as a constant within a fixed interval T. This interval is usually taken as a month or longer. This paper derives the formula for computing the expected error in the tidal prediction

caused by fixing the modulation factors within an interval *T*. (1 ref)

Kuo, C. Y., and Campbell, R. A. 1989. An overview of coastal stormwater drainage problems. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 711-716. New York: ASCE.

Considerable studies have focused on the drainage design in upland areas. In the Atlantic and Gulf coastal region, the stormwater drainage presents many unique problems due mainly to the flat terrains and the tidal effects. This paper presents the stormwater drainage design problems in the coastal environment. (16 refs).

†**Leendertse, J. J.** 1982. The relation between the semidiurnal tide in the eastern Scheldt and its overtides. Report RAND/N-1787-NETH. Santa Monica, CA: Rand Corporation.

An analysis of a 16-day record of water levels at stations in the Eastern Scheldt was conducted. It was found that the semidiurnal tidal amplification is strongly dependent on its tidal heights (tidal range). The lag of the semidiurnal tide is also influenced by the tidal range. The quarterdiurnal tidal range in the main part of the Eastern Scheldt increases nearly linearly with the range of the semidiurnal tide over the range from neap tide to spring tide. Proportionally, the quarterdiurnal tide increases much faster than the semidiurnal tide. This is not the case in the Volkerak where the quarterdiurnal tidal range decreases with increasing semidiurnal tide when the semidiurnal tidal range is larger than the average range. The sixth-diurnal tidal range increases also, nearly linearly, with the range of the semidiurnal tide except at Bruinisse which is close to a node in the system. Generally, the sixth-diurnal tidal range increases faster than the semidiurnal tidal range.

Leendertse, J. J. 1988. Influence of the advection term approximation on computed tidal propagation and circulation. (See complete entry in Section VIII.)

Li, C. W., Lee, J. H.-W., and Cheung, Y. K. 1986. Mathematical model study of tidal circulation in Tolo Harbour, Hong Kong: Development and verification of a semi-implicit finite element scheme. (See complete entry in Section VI.)

Lin, H.-C. J., and Martin, W. D. 1989. Newport News channel deepening study, Virginia; Numerical model investigation. (See complete entry in Section VI.)

Lin, P.-N., Huan, J., and Li, X. 1983. Unsteady transport of suspended load at small concentrations. (See complete entry in Section II.)

Lincoln, J. M., and Fitzgerald, D. M. 1988. Tidal distortions and flood dominance at five small tidal inlets in southern Maine. *Marine Geology* 82(3/4):133-148.

Maximum and mean flood current velocities exceeded ebb current velocities by an average of more than 20 cm s^{-1} at five small inlets along the southern coast of Maine. Distortion of the tidal wave as it interacts with these shallow inlets, such that the rising tide duration averages 3:22 hours less than the falling tide duration, may be the cause of flood current dominance at these inlets. Tide records from three locations at Ogunquit Inlet, located along the southern coast of Maine, show that the 29-day average tide duration asymmetry increases from a rising tide that is 0:07 hour longer than the falling tide for the offshore record to a rising tide that is 2:15 and 5:15 hours shorter than the falling tide for the inlet throat and bay records, respectively. Previous field studies and numerical models of tidal asymmetry have not examined tidal distortion in very shallow inlets where the channels shoal to depths shallower than the forcing tide amplitude. At the inlets investigated in this paper, channels are shallower than the ocean tide amplitude by an average of 30 cm. A model is presented that explains how the shallow inlet bathymetry truncates the ocean tide and produces an inlet tide characterized by an extended falling tide and a shortened rising tide duration. The dominance of flood tidal currents at these inlets produces net landward sediment transport. (18 refs)

Littlewood, A. 1987. A new approach to the presentation of tidal information. *The International Hydrographic Review* 64(1):141-146.

Based upon the Hull Tide Table of 1814, the author presents a new approach to the presentation of tidal information. No hydrographic, astronomical, or mathematical knowledge is required of the user. All one will require are tide tables, a pencil, ruler, and either a pair of parallel rulers or a square. The accuracy of Secondary Port tide times and heights is

to a higher standard than is available by Admiralty methods. The accuracy of intermediate tidal information is to the same standard for all ports and is equivalent to the accuracy of the Admiralty Standard Port diagrams. Diurnal port and tidal stream information is available by the same method.

Liu, J. 1986. A study on the siltation in the approach channel with different alignments of the Lianyun Harbour. (See complete entry in Section VIII.)

Loder, J. W., and Wright, D. G. 1985. Tidal rectification and frontal circulation on the sides of Georges Bank. *Journal of Marine Research* 43(3):581-604.

Using Wright and Loder's depth-dependent tidal rectification model and Garrett and Loder's diagnostic frontal circulation model, predictions of the residual circulation associated with the topographic rectification of tidal currents and the summertime density field on the northwestern and open ocean sides of Georges Bank are made and compared with observations. In general, the estimates of both wintertime and summertime along-isobath currents are in qualitative agreement with observations, but the agreement between predicted and observed cross-isobath currents is poor. The circulation associated with tidal rectification is primarily along isobaths in an anticyclonic sense around the bank at all depths. The cross-isobath circulation is much weaker and, in the Eulerian specification, is dominated by two cells with opposing current directions. However, a significant Stokes velocity is predicted such that the along-isobath Lagrangian current is generally less than its Eulerian counterpart, and the cross-isobath Lagrangian current is sometimes in the opposite direction to its Eulerian counterpart. Both the along-isobath and cross-isobath currents associated with tidal rectification are predicted to be significantly stronger in summer than in winter due to a reduction in the strength of friction as a result of reduced wind stress and increased density stratification. An additional contribution to the anticyclonic circulation around Georges Bank is associated directly with the summertime tidal front around the bank. This flow component is predicted to form a second intense along-isobath jet on the northwestern side, slightly offbank of that due to tidal rectification, and a broader flow on the open ocean side. The associated cross-isobath circulation is predicted to be much weaker than the along-isobath circulation, with a general onbank bottom flow on both sides of the bank. (31 refs)

†**Lorant, F. I.** 1981. Truro hydrotechnical study: A tidal flood plain analysis. In *Proceedings, 5th Canadian hydrotechnical conference,* 26-27 May 1981, Fredericton, Canada, 1:289-306. Montreal, Canada: Canadian Society of Civil Engineering.

This paper describes part of the Canada-Nova Scotia Flood Damage Reduction Programme, the Truro Hydrotechnical Study. It discusses the floodplain analysis which has to consider the Bay of Fundy high tides, high freshwater runoff, sea and river ice jams, and constriction of floodways by dikes and structures. The combined effect of astronomical and meteorological factors on tides and storm surges in the Bay and Salmon River Estuary are described. It presents design data flow curves of large watersheds and historical analysis on floods, many of which were caused by ice jams. Implications for flood prevention diking systems are outlined.

Lung, W.-S. 1986. Advective acceleration and mass transport in estuaries. *Journal of Hydraulic Engineering* 112(9):874-878. Discussion by Jerome Peng-Yea Maa and Flora Chu Wang and Closure by Wu-Seng Lung, 114(5):559-562.

Estuarine hydrodynamics and mass transport are important aspects of fate and transport modeling of pollutants in waste load allocations. One of the common problems in modeling studies associated with waste load allocations is the availability of hydrodynamic data. Although many complex three-dimensional time-variable estuarine hydrodynamic models are available, their input requirements usually far exceed the extent of data available. In many waste load allocations studies for estuaries, analysts have to settle for a reasonably simplified, yet scientifically credible framework of analysis for which data requirements can be readily met. The purpose of this paper is to present an analysis that assesses the effect of omitting the advective acceleration term on the computation of tidally averaged circulation and mass transport for partially mixed estuaries. The analysis shows that dropping the advective acceleration term has no effect on tidally averaged circulation and the mass transport calculation when the effect is lumped with the surface slope term. This further simplifies the task of quantifying mass transport in the modeling analysis of waste load allocations for estuaries (5 refs). Discussion (4 refs) and Closure (2 refs).

Lung, W.-S., and O'Connor, D. J. 1984. Two-dimensional mass transport in estuaries. *Journal of Hydraulic Engineering,* ASCE, 110(10):1340-1357.

Discussion by M. I. El-Sabh and T. S. Murty and Closure by Wu-Seng Lung, 113(6):799-801. Errata, 112(9):879.

On a tidally averaged basis, the two-dimensional estuarine circulation is characterized by a horizontal seaward velocity in the upper layer and a landward velocity in the lower layer, with a compensating vertical velocity to maintain hydraulic continuity. A relatively simple method of analysis is developed for this type of circulation from the hydrodynamic equations of momentum, continuity, and state. It is based on the condition that the salinity distributions in both the longitudinal and vertical directions are known or may be assigned. In addition to an analytical solution for the horizontal and vertical velocities, the analysis generates the values of vertical eddy viscosity which characterizes the vertical exchange of momentum, an important process of circulation in partially mixed estuaries. Successful applications of the analysis to a number of estuaries throughout the country prove that the present method is efficient and simple to use. The present method of analysis offers a definite advantage as a first approximation to this type of estuarine circulation (30 refs). Discussion (4 refs).

McCave, I. N. 1979. Tidal currents at the North Hinder Lightship, southern North Sea: Flow directions and turbulence in relation to maintenance of sand banks. (See complete entry in Section VIII.)

†**McCoy, S. E., and Watson, W. A.** 1984. Georgia estuaries circulation survey. In *HYDRO '84, Hands on to high tech,* Proceedings, National Ocean Service Hydrographic Conference, 25-27 April 1984, Rockville, MD, 36-41. Rockville, MD: Hydrographic Society.

The 1980 Circulation Survey, Southeast Atlantic Coast Estuaries, Sapelo Sound to St. Andrew Sound, Georgia, was conducted from March through June 1980 by the National Oceanic and Atmospheric Administration's Ship *Ferrel.* Sapelo Sound, Doboy Sound, Altamaha Sound, St. Simons Sound, and their tributaries (collectively referred to as Georgia Estuaries) were studied. Current, tide, meteorological, and conductivity-temperature/depth data were collected. These data were processed and harmonic and nonharmonic analysis results are presented. Investigative methodology and findings with respect to physical characterizations of the Georgia Estuaries are discussed. Findings are important for understanding the physical and ecological dynamics of the region.

McCoy, S. E., Long, E. E., and Dingle, G. 1984. Analysis of current meter data collected at Chesapeake Bay entrance from 1981 to 1983. In *Oceans '84 conference record: Industry, government, education...Designs for the future,* 10-12 September 1984, Washington, DC, 2:979 (abstract only). Piscataway, NJ: The Institute of Electrical and Electronics Engineers, Inc.

The National Ocean Service (NOS) conducted a three-phase, 2-1/2-year project from August 1981 through December 1983, to obtain physical oceanographic and meteorological data for the Chesapeake Bay. Harmonic analyses of 87-day, 58-day, 29-day, and 15-day records were performed on current data from long-term station 40, Chesapeake Bay entrance. This long-term station was important for the analysis of low-frequency currents and for the computation of accurate tidal current predictions. Station 40 is planned to be published as a predicted reference station in the NOS "Tidal Current Tables 1985 - Atlantic Coast of North America." Circulation data from the Chesapeake Bay Circulation Project will be provided to aid safe navigation and environmental management. Moreover, these data will aid in interpreting the hydrodynamics of the Bay. Interpretations of data analyses with respect to comparisons of tidal current characteristics are discussed.

Maas, L. R. M., and van Haren, J. J. M. 1987. Observations on the vertical structure of tidal and inertial currents in the central North Sea. (See complete entry in Section VIII.)

Malone, F., Kuo, J. T., and Chen, N. M. 1982. Finite element modeling of tides and currents of the New York Bight. (See complete entry in Section VI.)

Marmorino, G. O. 1983. Summertime coastal currents in the northeastern Gulf of Mexico. *Journal of Physical Oceanography* 13(1):65-77.

This paper presents an analysis of observations of currents and temperature from a mooring on the inner part of the West Florida Shelf in the northeast corner of the Gulf of Mexico taken in late summer. From the analysis, tidal currents accounted for 85 percent of the observed kinetic energy, and frictional effects gave rise to a veering with depth of both the low-frequency flow and the energetic, counterclockwise-rotating twice-daily tidal currents. (23 refs)

Marsden, M. A. H. 1979. Circulation patterns from seabed-drifter studies, Western Port and Inner Bass Strait, Australia. *Marine Geology* 30(1/2):85-99.

Seabed drifters were used to investigate bottom-water movements in Western Port, Victoria, Australia, and in nearby parts of Bass Strait. The objective was to document circulation in and around the entrance areas and also throughout the bay, placing emphasis on smaller scale patterns associated with net flood or ebb movements. Approximately 2,000 seabed drifters were released in close-spaced arrays, half between November and December 1974, during the summer wind regime, and the other half in September-October 1975, before the onset of the summer wind regime. The 1974 deployment was made along 26 transects located throughout the major and minor channels of the bay and its entrances and in Bass Strait. Groups of 5-15 drifters were released at any station. The 1975 deployment was based on the 1974 results and release stations were chosen to elucidate specific characteristics previously observed and also to document the characteristics of bottom-water movement associated with spring and neap tides. Drifter returns were 37 percent for the 1974 releases and 16 percent for 1975. These numbers were adequate to clearly define the patterns of bottom-water movement in and around the bay. In some cases drifters were retrieved by fishing boats so that drift rates could be computed. Results show an eastward movement of bottom waters in Bass Strait with net speeds of 2.3 cm/sec (1.9 km/day). The main net inward movement of water to the bay is through the western side of the western entrance with an ebb-dominant zone existing on the eastern side. At the eastern entrance, evidence of net movement is inconclusive. Detailed circulation patterns for eight smaller-scale features have been recognized, and these are often closely related to the morphology of various segments of the bay. The net movement within the bay is clockwise around French Island. (12 refs)

Marsden, M. A. H., Mallett, C. W., and Donaldson, A. K. 1979. Geological and physical setting, sediments and environments, Western Port, Victoria. (See complete entry in Section II.)

Marsden, R. F. 1986. The internal tide on Georges Bank. (See complete entry in Section VIII.)

Mayer, D. A., Leaman, K. D., and Lee, T. N. 1984. Tidal motions in the Florida Current. (See complete entry in Section VI.)

Mehta, A. J., and Joshi, P. B. 1988. Tidal inlet hydraulics. *Journal of Hydraulic Engineering, ASCE,* 114(11):1321-1338.

The unique physiographic features of tidal inlets make it convenient to treat inlet hydraulics in two parts, one pertaining to the channel through the land barrier, and the other to the near-field region characterized by ebb and flood circulations beyond the channel. Theoretical formulations for flow description in these regions lead to approximate but useful analytic solutions in simple cases. For detailed hydraulic description, physical and numerical modeling techniques are widely employed. Limitations in predictive capabilities seem to arise mainly from a lack of fuller understanding of hydromechanical process. Such interactive phenomena as the propagation of the buoyant jet through ambient seawaters during the ebbing phase of tidal flow and the influence of waves on the tidal flow regime require considerable additional scrutiny via field investigations. The complex nature of inlet behavior necessitates the collection of site-specific prototype information as an essential component of hydraulic analysis and interpretation. (67 refs)

Meyer, Z., and Buchholz, W. 1988. Hydrology and hydrodynamics of the Odra Estuary with special reference to the influence of wind. *Bulletin of the Permanent International Association of Navigation Congresses* 60:64-76.

The article presents the factors which constitute the hydrology and hydromechanics of river mouths with special attention paid to the effect of wind, this being of great importance for the estuary of the Odra. Analysis of this phenomenon enabled the formulation of a mathematical model of a tactoid with the influence of wind taken into account and its introduction into the mathematical model of the Odra estuary in order to define the phenomenon of wind backwater. Technical aspects of wind backwater have been presented with special attention paid to the safety of navigation, protection of aquatic environment and flood protection. (10 refs)

†**Miller, A. J.** 1986. Barotropic planetary-topographic oscillations in ocean basins. Ph.D. diss., University of California, San Diego.

Basin-scale, low-frequency, linear fluctuations in idealized, rotating ocean basins with planetary and/or topographic vorticity gradients are discussed in three free-standing chapters. In Chapter I, free vorticity

modes are numerically computed for square, midlatitude ocean basins with topography. It is found that strong coupling between planetary (Rossby) modes and topographic (shelf, ridge, or seamount) modes can occur. This results in the generation of families of modes, the members of which exhibit spatial structures and time scales comparable to a flat-bottom counterpart mode. The mechanism provides an alternative to strong dissipation as an explanation for broadbandedness in spectral observations of planetary modes. It is found in Chapter II that mesoscale turbulence, when confined to western-boundary regions of numerical models, can efficiently excite basin modes at resonance, with (parameterized) bottom friction limiting the response. Furthermore, the midocean mesoscale eddy field, driven by Rossby-wave radiation from the turbulent region, is found to be remarkably similar to that of a stochastic-wind-driven model. This suggests that fluctuating winds and boundary-current radiation may be of comparable import as sources for the open-ocean mesoscale field. Topography is observed to significantly alter the amplitude but not the nature of the model fluctuations. The long-period tides are discussed in Chapter III in the light of recent observations and theories. Quasi-geostrophic solutions which include topography and friction are computed. Friction is found to decrease the effects of bottom roughness in the quasi-geostrophic models. The divergent velocity field associated with a nearly equilibrium tide is found to be comparable to equilibrium-tide vortex stretching in driving quasi-geostrophic flows. However, quasi-geostrophic solutions are shown to be insufficient for interpreting the observations. A divergent velocity field is suggested to be an important element of future long-period tide models. The results suggest that oceanic planetary modes may yet be observed once calculations are extended to realistic basins and sea-level records are properly interpreted. Oceanic mesoscale turbulence may excite rather than dissipate basin, or sub-basin, modes, thus providing an excitation mechanism distinct from atmospheric forcing. Understanding the oceanic response to long-period tidal forcing provides an important benchmark for oceanic circulation theory.

†**Mofjeld, H. O.** 1982. Recent observations of tides and tidal currents from the Northeastern Bering Sea Shelf. (See complete entry in Section VI.)

†**Morant, P. K., Bickerton, I. B., Heydorn, A. E. F., and Grindley, J. R. ed.** 1983. Estuaries of the Cape; Part 2: Synopses of available information on individual systems; Report 19: Groot (WES) (CMS 23) and Sout (CMS 22). Stellenbosch, South Africa: National Research Institute for Oceanology.

Information on the Greek and South Estuaries is summarized. Historical background, abiatic characteristics, river catchment, flora, fauna, maps, and aerial photographs are described.

†**Morant, P. D., and Grindley, J. R., comp.** 1982. Estuaries of the Cape; Part 2: Synopses of available information on individual systems; Report 14: Sand (CSW 4). Stellenbosch, South Africa: National Research Institute for Oceanology.

Information is summarized on various aspects of the Sandvlei estuaries of the Cape region of the Republic of South Africa. Among the topics discussed are rivers, public health, land ownership and use, water pollution, plants and animals.

Moses, J. E., and Blair, C. 1988. Prediction of tidal surge in lower Chesapeake Bay. *Journal of Waterways, Port, Coastal, and Ocean Engineering*, ASCE, 114(2):248-256.

Tidal surge is the difference between observed water level and predicted astronomical tide. At present, surge predictions for Sewell's Point, Virginia, rely on Pore's hurricane surge model, a linear combination of forecast surface pressures over a large portion of the Atlantic Ocean. A variation on this method has been developed by including previous surge, local wind, and local pressure terms with time lags of up to 18 hr to predict local daily surge. Surge prediction equations were derived for three substations 15-120 km (8-65 nautical miles) from Sewell's Point. Surge predictions at all four stations were improved at least 23 percent by the new regression equations. The ease in using the new equations and their improved accuracy make these new equations preferable to the Pore prediction method. The procedure described in this article is especially useful to shippers, property owners, and others with limited data sources. (10 refs)

Müller, K.-D., and Schwarze, H. 1988. Some studies to reduce sedimentation in a port on a tidal river. (See complete entry in Section II.)

†**Nair, R. R.** 1984. The Indus paradox. *New Science* 101(1397):40-42.

This paper discusses the distribution of sediment observed in a study of sediment flow from the Indus. The abnormal variations are explained by the concept

of dynamic barriers. When the sediment-laden coastal current (southwest monsoon drift) encounters the strong tidal currents at the mouth of the Gulf of Kutch, the surface current is deflected from its southerly flow to the west, sending sediment into deeper waters of the continental slope and starving the Saurashtra coast (to the south) of sediment. It discusses the behavior of the tidal barrier as a crude filter. Bed-load material is certainly deflected, but extremely small particles can pass through. As the Gulf of Kutch receives no sediment from its head or sides, siltation is not likely to be a problem at the proposed tidal power station at this site.

Nakamura, S. 1987. A note on numerical evaluation of tsunami threats by simple hydrodynamic and stochastic models referring to historical descriptions. *Bulletin of the Disaster Prevention Research Institute* 37(1):1-18. Kyoto, Japan: Kyoto University.

This work is a speculative study to clarify what is essential for hydrodynamic or stochastic studies of the tsunamis and what is important in the historical descriptions and the tsunami catalogs for numerical simulation and prediction and for stochastic evaluation of practical tsunami protection works. First, a brief description of the historical documents of past tsunamis are introduced and evaluated in order to give a local chronological tsunami catalog which will aid in understanding what should be noted in reading the tsunami descriptions. In addition to the descriptive tsunamis, numerical simulation of the past tsunamis were reviewed and evaluated. The author's finite difference method with a uniform grid spacing is introduced in order to show a simulation of a tsunami. The author has used a uniform grid spacing in his numerical model because he knows that it is helpful in minimizing the truncation error in a numerical model of a finite difference method. In any numerical simulation case, the historical descriptions are the essential references to confirm how successful the simulation is. Although no numerical model can predict when the next tsunami occurs, the stochastic model is now very useful in making probabilistic predictions. This measure is for long-term practical planning of tsunami protection works with reliable references selected from the historical documents of the past tsunamis and the tsunami catalogs well revised. (32 refs)

Nakamura, S. 1987. A numerical prediction of semidiurnal current patterns in Tanabe Bay. *Bulletin of the Disaster Prevention Research Institute* 37(3):91-105. Kyoto, Japan: Kyoto University.

The study of tidal currents in Tanabe Bay has a long history which is related to the fields which cover coastal hazards as will as study of physical oceanography and biological oceanography. In this study, the dynamics of Tanabe Bay are studied by using a model of a finite difference method with comments on the previous observations of tidal currents in Tanabe Bay. In order to get a reasonable solution from the author's model, as has been done in the other cases, it is necessary to consider first how to choose the initial conditions of the dynamic factors concerned. Although the effects of the so-called Kuroshio Current coastal waters and meteorological effects are occasionally significant in the area of interest, the simple semidiurnal oscillation in the model is considered and compared to the previously observed current velocity of M_2 constituent in this model. The flow patterns at the peak ebb and peak flood in the model are compared to the flow patterns for the resonant mode with an offshore node of Tanabe Bay as a wide-open bay. (26 refs)

Nece, R. E., and Smith, H. N. 1982. Photodensimetric methods in tidal flushing studies. (See complete entry in Section VI.)

Nichols, M. M. 1986. Storage efficiency of estuaries. (See complete entry in Section II.)

Nihoul, J. C. J., and Jamart, B. M., ed. 1987. *Three-dimensional models of marine and estuarine dynamics.* (See complete entry in Section VI.)

Nunes, R. A., and Simpson, J. H. 1985. Axial convergence in a well-mixed estuary. *Estuarine, Coastal and Shelf Science* 20(5):637-649.

Transverse secondary circulations involving surface convergence, observed in a well-mixed estuary in North Wales, are made visible by the collection of surface material along an axial line which extends continuously for many kilometres through the estuary. The circulation and axial convergence, however, are seen only during the flood phase of the tide, and no similar behavior has been observed during the ebb phase. Convergent circulations in the estuary are associated with small but steady transverse density gradients in the cross section, produced by nonuniform advection of the longitudinal gradient through the channel. A diagnostic model, using measured mean distributions of cross-sectional density, indicates surface transverse velocities ($\sim 0.1\ ms^{-1}$) similar to those observed in the estuary. The model further predicts appreciable transverse divergent currents at a fractional depth of 0.75, a

prediction which has been tested in the estuary using a vertical array of accurately resolving current direction indicators. (14 refs)

Odd, N. V. M., Wolfe-Barry, J. N., and Berrahim, A. 1985. Hydraulic modelling of a tidal lagoon at Benghazi. (See complete entry in Section VI.)

Oey, L.-Y., Mellor, G. L., and Hires, R. I. 1985. A three-dimensional simulation of the Hudson-Raritan Estuary; Part I: Description of the model and model simulations. (See complete entry in Section VI.)

Oey, L.-Y., Mellor, G. L., and Hires, R. I. 1985. A three-dimensional simulation of the Hudson-Raritan Estuary; Part II: Comparison with observation. (See complete entry in Section VI.)

Oey, L.-Y., Mellor, G. L., and Hires, R. I. 1985. A three-dimensional simulation of the Hudson-Raritan Estuary; Part III: Salt flux analyses. (See complete entry in Section III.)

Oey, L.-Y., Mellor, G. L., and Hires, R. I. 1985. Tidal modeling of the Hudson-Raritan Estuary. (See complete entry in Section VI.)

O'Keeffe, P., and Harding, P. 1985. The combined use of mathematical and physical models to represent the tidal behaviours of Gladstone Harbour. (See complete entry in Section VI.)

†**Olson, P.** 1984. Spectral model for subtidal variability in the Chesapeake Bay. (See complete entry in Section VI.)

Olson, P. 1986. The spectrum of subtidal variability in Chesapeake Bay circulation. *Estuarine, Coastal and Shelf Science* 23(4):527-550.

The advent of long, continuous time series records of circulation in Chesapeake Bay has revealed the existence of large amplitude fluctuations within the subtidal range 0.03-0.6 cycles day^{-1}. These fluctuations represent direct and indirect response of the estuary to variations in wind stress, freshwater inflow, and coastal sea level. The fluctuations in circulation are accompanied by synchronous fluctuations in transportable properties such as salinity and temperature. A quantitative model is presented to explain this variability within the main stem of Chesapeake Bay in terms of a linear reponse to irregular, time-varying meteorological forcing. The model calculates transfer functions and energy spectra of laterally averaged transport, surface elevation, and salinity in two layers separated by a halocline, over the frequency band 0.03-0.6 cycles day^{-1}. Transfer functions between volume transport and wind stress obtained from 1-month-long field experiments at three different cross sections in Chesapeake Bay are used to constrain model friction parameters. Using existing estimates for wind stress and coastal sea level energy spectra, energy spectra for volume transport and surface elevation are calculated as a function of longitudinal position. It is found that the observed volume transport spectrum at the mouth of the bay can be explained quantitatively as the combined response to statistically independent wind stress and sea level fluctuations. Variations in sea level account for 90 percent of the volume transport variance at the bay mouth and dominate the volume transport spectrum below 0.375 cycles day^{-1}. In the upper bay, longitudinal wind stress accounts for most of the variance. A maximum in the volume transport spectrum at 0.4 cycles day^{-1}, caused by a local maximum in the wind spectrum, is found at all upper bay cross sections. (15 refs)

Ostendorf, D. W. 1984. Linearized tidal friction in uniform channels. *Journal of Hydraulic Engineering*, ASCE, 110(7):867-885.

Existing models of tidal motion in narrow, uniform channels are improved by incorporating a spatial application of Lorentz' principle of equivalent work into the characteristic velocity and tidal friction factor estimates used to linearize the bottom shear stress. The characteristic velocity is evaluated using numerical integration. A steady flow analogy is involved to relate the tidal friction factor to channel roughness and fluid viscosity. These two parameters in turn yield expressions for the viscous wave number, damping modulus, and damping frequency which describe the wave motion. The procedure is applied to existing analyses of closed-end and sea level canals, and models are tested against laboratory and field data with accurate and physically plausible results. (31 refs)

Otvos, E. G. 1981. Barrier island formation through nearshore aggradation--Stratigraphic and field evidence. *Marine Geology* 43(3/4):195-243.

Extensive core drilling in the Mississippi Sound and the Mississippi barrier island chain and preliminary subsurface data from Apalachicola Bay and its barrier islands, northeast Gulf of Mexico, provided stratigraphic information to show the existence of open marine mainland shores here during late

Holocene times until the emergence of the ancestors of present-day island chains. Ample field evidence exists for the emergence and evolution in historic and recent times of numerous small and several sizable barrier islands at Gulf locations and elsewhere, including a few islets on the Atlantic coast. The emergence process involves development, by various means, of shallow platform areas on which subtidal shoals may form. Where such shoals are protected from the erosive effects of the breaker zone, wave bore currents transport sand over the shoals and accrete them to low intertidal-highest tide levels. This occurs during fair-weather periods when constructive deepwater waves dominate. Initial stabilization of embryonic islands is accomplished by seaward widening of berms, the emergence of new intertidal bars seaward of the earlier ones, and addition of sand through overwash. Spit growth, aided by emerging bars downdrift from the island core area, may also be essential in early stages for the islands' survival. Evolution through vertical aggradation, the earliest advocated mode of barrier island formation, remains the only widely documented process by which primary barrier islands are constructed. (50 refs)

Outlaw, D. G., and Butler, H. L. 1982. Model verification using tidal constituents. (See complete entry in Section VI.)

Park, Y.-H. 1986. Semidiurnal internal tides on the continental shelf off Adbidjan. *Journal of Physical Oceanography* 16(9):1585:1592.

Important semidiurnal internal tides with a maximum displacement of isotherms of about 30 m were observed on the continental shelf, near the submarine canyon Trou-Sans-Fond off Abidjan, Ivory Coast. It is proposed from a two-layer submarine canyon model experiment that the observed internal tides could have been generated by an interaction between the bottom topography of the submarine canyon and oscillatory longshore tidal currents and have propagated away on both sides of the canyon. The estimated wavelength and phase speed of the M_2 internal tides of the region were respectively 22 km and 0.5 m sec^{-1}. The asymmetric profiles of isotherms and baroclinic currents were explained in terms of the nonlinear effects of the internal waves. (22 refs)

†**Parker, B. B.** Frictional effects on the tidal dynamics of a shallow estuary. Ph.D. diss., The Johns Hopkins University, Baltimore, MD.

This study demonstrates the dominant role played by friction in determining the tidal characteristics of a shallow estuary and in providing a mechanism for the coupling of tidal and nontidal phenomena. Nonlinear frictional effects, which have generally received little attention, are shown to be at least as important as the effects of the so-called "shallow-water" terms (i.e., the nonlinear continuity term and the inertial (convective) term). Frictional mechanisms are important in the transfer of energy and momentum among the tidal frequencies and in the interaction of the tide with riverflow and low-frequency storm surge, through either (a) the quadratic term, $u \mid u \mid$; (b) the term representing the variation in frictional effect due to changing elevation; or (c) first-order frictional effects via the nonlinear continuity term. Friction plays an dominant role in the tidal dynamics of a shallow estuary because of the low frequencies involved. Frictional effects increase with decreased depth, increased tidal amplitude, or decreased frequency. The friction term is shown to have two nonlinear aspects: (a) the "quadratic" part, $u \mid u \mid$, and (b) the part representing the elevation effect on frictional momentum loss per unit volume of fluid, which produces the same effects as the "shallow-water" terms, and is more important in the Delaware Estuary than the inertial term. This elevation/frictional effect generates even harmonic overtides; generates terdiurnal, quarter-diurnal, and low-frequency compound tides; generates tidally induced changes in mean sea level; provides a coupling mechanism whereby low-frequency storm surge and local wind setup or setdown affect the tidal amplitude and phase; and provides a mechanism for the smearing of tidal spectral lines (tidal "cusps") by low-frequency storm surges. The effect of the nonlinear continuity term, which plays the other important role in these effects, is shown to depend on first-order (linear) frictional effects. The quadratic friction term, $u \mid u \mid$, generates odd harmonic overtides; generates semidiurnal and higher frequency compound tides; provides the mechanism whereby the amplifications of smaller astronomical constituents are reduced due to the presence of a larger constituent; and provides the mechanism whereby riverflow reduces the tide range and generates even harmonic overtides.

Pearson, C. A., Schumacher, J. D., and Muench, R. D. 1981. Effects of wave-induced mooring noise on tidal and low-frequency current observations. (See complete entry in Section VIII.)

Pearson, C. E., and Winter, D. F. 1984. On tidal motion in a stratified inlet, with particular reference to boundary conditions. (See complete entry in Section VIII.)

Pejrup, M. 1986. Parameters affecting fine-grained suspended sediment concentrations in a shallow micro-tidal estuary, Ho Bugt, Denmark. (See complete entry in Section VI.)

Pelegrí, J. L. 1988. Tidal fronts in estuaries. *Estuarine, Coastal and Shelf Science* 27(1):45-60.

Three estuaries in Wales were carefully surveyed during flood conditions. They are characterized by the intrusions of a tidal front. In one estuary the front retreats after maximum flood velocities and stratification persists during the whole tidal cycle. In the other estuaries the flood erases the initial stratification causing partially or totally mixed situations. A tidal Froude number is employed to characterize the evolution of stratification during the flood. It is shown that gravity current theory approximately holds under well-stratified conditions in a region near to, but not too close to, the head of the front. (23 refs)

Picaut, J., and Verstraete, J. M. 1979. Propagation of a 14.7-day wave along the northern coast of the Guinea Gulf. *Journal of Physical Oceanography* 9(1):136-149.

Long time series of sea level and sea surface temperatures measured at different coastal stations along the northern coast of the Gulf of Guinea are analyzed statistically. The results indicate that pronounced fortnightly oscillations in sea level are composed of two waves: one is the lunar fortnightly tide Mf (13.661-day period) which has a constant phase all along the coast. The other wave has a period of 14.765 days which is the period of the luni-solar fortnightly tide Msf; this wave propagates westward along the eastwest oriented coastline with a mean phase speed of 53 cm sec^{-1} and a wavelength of 675 km. These waves have important effects on the thermal structure and give rise to strong vertical oscillations of the subsurface isotherms throughout the year. The sea surface temperature, however, has pronounced oscillations around the Msf frequency during the upwelling season (June-September) only. The 14.765-day wave is of tidal origin and is due to a nonlinear interaction of the M_2 and S_2 (barotropic or baroclinic) tides but the generation mechanism is obscure. (42 refs)

Pickard, G. L. Effects of wind and tide on upper-layer currents at Davies Reef, Great Barrier Reef, during MECOR (July-August 1984). *Australian Journal of Marine and Freshwater Research* 37(5):545-565.

At Davies Reef, flow over the east reef flat was unidirectional downwind at 10-20 cm sec^{-1} with strong winds and smaller tides but was semidiurnal tidal reversing at 5-15 cm sec^{-1} with lighter winds and higher tides. The flood direction was to the southeast out of the lagoon and the ebb into the lagoon. Wave overtopping was estimated to contribute at least 40 percent of the flow over the reef flat--the first estimate of this component of flow over reef flats. Transit times over the reef flat were 30-170 min and flushing times for the east lagoon were estimated as 1/5-1 day for strong winds to the northwest but 2-4 days for lighter winds. In the east lagoon, the upper-layer currents were semidiurnal tidal reversing all the time at speeds up to 20 cm sec^{-1}, with longer term net flow downwind at about 2 cm sec^{-1} with strong winds but upwind at 0.2 cm sec^{-1} with light winds. In the east passage, the strongly tidal currents (up to 60 cm sec^{-1}) had a long-term net flow to the south at about 2 cm sec^{-1} without any clear correlation with the wind. (6 refs)

Pingree, R. D. 1983. Spring tides and quadratic friction. (See complete entry in Section VI.)

Pingree, R. D., and Maddock, L. 1979. The tidal physics of headland flows and offshore tidal bank protection. (See complete entry in Section VI.)

Pingree, R. D., Mardell, G. T., and Maddock, L. 1985. Tidal mixing in the Channel Isles region derived from the results of remote sensing and measurements at sea. (See complete entry in Section VIII.)

†Pirie, D. M., and Steller, D. D. 1977. California coastal processes study--Landsat II, final report. (See complete entry in Section VIII.)

Pizzuto, J. E. 1986. Barrier island migration and onshore sediment transport, southwestern Delaware Bay, Delaware, U.S.A. (See complete entry in Section II)

Platzman, G. W. 1984. Normal modes of the world ocean; Part III: A procedure for tidal synthesis. (See complete entry in Section VI.)

Platzman, G. W. 1984. Normal modes of the world ocean. Part IV: Synthesis of diurnal and semidiurnal tides. (See complete entry in Section VI.)

Ports, M. A., ed. 1989. *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA. New York: ASCE.

The papers in this book were presented at the ASCE National Conference on Hydraulic Engineering in August 1989 at New Orleans, Louisiana. The objective of the conference was to provide a forum for discussion and exchange of information on issues related to hydraulic engineering. Papers discussing hydraulic structures review their analysis, design, rehabilitation, and upgrading as well as scour and discharge estimates. The hydraulics of sewers, culverts, and other closed conduits are also included. Rough flow in shallow channels, channel stability, unsteady open channel flow, and river mechanics are considered. A number of papers focus on coastal and estuarine systems and processes, the impacts of global climate change, applications of geographic information systems, and probabilistic approaches to hydraulic engineering. Other topics presented include physical hydraulic models, water distribution systems, computational hydraulics, groundwater monitoring and analysis, geostatistics, dam safety, precipitation and droughts, and techniques and issues in urban hydrology.

Prandle, D. 1985. On salinity regimes and the vertical structure of residual flows in narrow tidal estuaries. (See complete entry in Section III.)

Prandle, D. 1987. The fine-structure of nearshore tidal and residual circulations revealed by H. F. radar surface current measurements. *Journal of Physical Oceanography* 17(2):231-245.

Using the Ocean Surface Current Radar (OSCR) developed by the Rutherford-Appleton Laboratory (UK), 30 days of synoptic hourly surface current vectors were obtained for 84 locations within a nearshore region some 18 km square. Tidal analyses of these data show that the currents associated with the predominate M_2 constituent sweep smoothly and regularly through the area, unaffected by the finer topographic features. Moreover, contours of the amplitude of the M_2 semimajor axis are mutually consistent to a precision of better than 0.5 cm sec^{-1}. Statistical analyses of these data indicate that the standard error of OSCR current measurements is less than 4 cm sec^{-1}. By contrast the major higher harmonic constituent, M_4, shows pronounced, but ordered, spatial variability. Relating the observed distributions for M_4 and M_2 is foreseen as an instructive modeling problem that should advance the knowledge of shallow water tidal interaction processes. Standard relationships between residual surface currents and the associated wind forcing accounted for only typically 30 percent of the current variance. However, by using the empirical orthogonal function technique a single mode was found to be responsible for up to 90 percent of the total variance with a mean value of 66 percent over the complete set of measurements. While the time-series for the (complex) amplitude of this model showed significant correlation with the wind-stress time-series (0.73 E-W and 0.32 N-S), the former was characterized by much longer period oscillations. The velocity vectors of this mode were almost uniformly aligned but varied in amplitude by a factor of 2. Thus, a low-frequency "slablike" surface current response to wind forcing is indicated. However, this response includes indirect components possibly involving modifications to current structure due to changes in density fields and nearshore influences. (16 refs)

Prandle, D., and Rahman, M. 1980. Tidal response in estuaries. *Journal of Physical Oceanography* 10(10):1552-1573.

A new general theory has been developed to determine both the tidal response of estuaries and the effects of cross-channel tidal barriers on this response. The theory is shown to be widely applicable and provides a connecting framework against which the response of different estuaries can be compared. (14 refs)

Prinsenberg, S. J. 1988. Damping and phase advance of the tide in western Hudson Bay by the annual ice cover. (See complete entry in Section VIII.)

Prinsenberg, S. J., and Bennett, E. B. 1989. Vertical variations of tidal currents in shallow land fast ice-covered regions. *Journal of Physical Oceanography* 19(9):1268-1278.

Arctic tidal currents with periods near the local inertial period are strongest and rotate clockwise at mid-depth, and decrease in amplitude toward the bottom and the ice cover, experiencing a change in direction of rotation of the current vector to counterclockwise near the boundaries. Such observations are explained by analytical solutions to a simple model in which the current vector of frequency ω is the sum of

oppositely rotating components. The frictional boundary layer thickness is proportional to $(\omega \pm f)^{-1}$, and therefore is markedly different for the two components. In the case of semidiurnal tidal components at high latitudes, the positive rotary component has a thin boundary layer and dominates near the boundaries, whereas the negative rotary component with a much larger boundary layer dominates at middepth. For a two-layered ocean, a set of particular solutions is used to verify the observed vertical variations in velocity components with maxima occurring at the interface between the two layers (pycnocline). A general solution consisting of the sum of particular and homogeneous solutions is also presented for the condition when the maxima in velocity components occurs away from the interface. (10 refs)

Pritchard, D. W., and Vieira, M. E. C. 1984. Vertical variations in residual current response to meteorological forcing in the mid-Chesapeake Bay. (See complete entry in Section VIII.)

†**Pugh, D. J.** 1982. Estimating extreme currents by combining tidal and surge probabilities. *Ocean Engineering* 9(4):361-372.

The need to obtain realistic estimates of extreme currents for the design of offshore structures requires optimum use to be made of the data available. Methods of applying joint tide surge probability techniques to the data are considered, and illustrated by analysis of 1 year of current meter observations in the North Sea. Tidal and meteorological induced vector components of the total observed current vector are isolated and their separate two-dimensional frequency distributions are computed. These distributions are then recombined to give probabilities of extreme total currents from several directions.

Ramsay, P. J., Cooper, J. A. G., Wright, C. I., and Mason, T. R. 1989. The occurrence and formation of ladderback ripples in subtidal, shallow-marine sands, Zululand, South Africa. *Marine Geology* 86(2/3):229-235.

Until recently ladderback ripples have been considered diagnostic of late-stage emergence runoff in intertidal environments. Observations have demonstrated that ladderback ripples may also occur in the subtidal environment. New underwater observations off the Zululand coast support Reddering's assertion that ladderback ripples are not confined to tide-dominated environments. Two types of ladderback ripple are described. They form in shallow, submarine bioclastic and terrigenous sediments, on the landward margin of offshore coral reefs. The main ripple set in each instance is oriented subparallel to the shoreline and is produced by the dominant southeasterly swell, while superimposed ripple sets in the troughs of the larger sets are formed by two mechanisms: (a) the approach of low-amplitude, high-frequency northeasterly to easterly swells which are not sufficiently strong to change the orientation of the dominant larger set, and (b) longshore currents produced by oblique wind-driven swells in small coastal embayments. When conditions change, the superimposed ripples are rapidly reworked and incorporated into the main ripple set. They therefore have a low preservation potential. Both the occurrences documented here and those reported previously are in microtidal, wave-dominated settings. (26 refs)

Reinson, G. E. 1977. Tidal-current control of submarine morphology at the mouth of the Miramichi Estuary, New Brunswick. *Canadian Journal of Earth Sciences* 14(11):2524-2532.

The mouth of the microtidal Miramichi Estuary, New Brunswick, is enclosed by a barrier-island system which is cut by two major tidal inlets. The submarine morphology adjacent to these inlets indicates the presence of large tidal deltas which formed predominantly by tidal-current processes. The extensive shoal water on the landward side of the barrier is due to the landward transport of sand through the inlets and the deposition of this sand as coalescing flood-tidal delta deposits. The creation of an artificial channel inside the main inlet in the late 19th century, and its maintenance since that time, have resulted in substantial channel flow bypassing of the natural channel seaward of the barrier. This promoted the scouring of a new channel through the ebb-tidal delta shoal. Large tidal deltas apparently are not common morphological features of estuaries on microtidal, barrier island coastlines, but they do occur at the entrances of very large microtidal estuaries such as the Miramichi. In such cases they are usually completely subtidal, and much larger than tidal deltas of mesotidal estuaries reported in the literature. Rather than tidal range, the tidal prism, which takes into account both tidal range and estuary surface area, may play the major role in the formation of tidal deltas in both mesotidal and microtidal estuaries. (21 refs)

Richards, D. R. 1988. New Haven Harbor numerical model study. (See complete entry in Section VI.)

†**Richmond, B. M., Nelson, C. S., and Healy, T. R.** 1984. Sedimentology and evolution of Ohiwa

Harbour, a barrier-impounded estuarine lagoon in Bay of Plenty. *New Zealand Journal of Marine and Freshwater Research* 18(4):461-478.

Ohiwa Harbor is a 24-sq-km estuarine lagoon impounded by the 6-km-long Ohope spit in the west and the 0.7-km-long Ohiwa spit in the east. These barrier sand spits are presently separated by a c. 340-m-wide inlet channel where the maximum harbor depth of 14 m occurs. Seventy percent of the harbor consists of tidal flats supporting a rich shelly benthos and diversified by stands of mangrove and backed locally by salt marsh. Lower harbor sediment in barrier beach, dune, and entrance shoal and channel environments are well sorted, negatively skewed, medium to fine sands. In contrast, upper harbor sediments are poorly to very poorly sorted, positively skewed, medium to very fine (silty) sands, the coarser of these deposits occurring in channel and restricted harbor beach environments, and the finer in intertidal flat, creek, and channel bank areas. The terrigenous mineralogy is consistent with a dominantly acid volcanic provenance, directly from the tephra mantle of the catchment and, most importantly, indirectly from the oceanic littoral zone. Sediment dispersal is dominated by tidal currents. Speeds decrease systematically up-harbor from maximum values of 100-150 cm/sec at the inlet channel to 5-10 cm/sec in upper harbor reaches. Current ripples, megaripples, and sand waves characterize the high-energy, current-dominated lower harbor deposits, whereas small-scale current and wave ripples, together with biogenic markings and burrows, characterize the lower energy, inner harbor deposits. Small-amplitude, wind-forced waves are important for resuspending and moving sediment in intertidal areas, particularly on the upper tidal flats. Most areas of the harbor are affected by biological processes. Rapid growth of Ohope barrier spit resulted from increased eastward transport of littoral sands around Whakatane Heads, west of Ohiwa Harbor. The probable cause of this was the infilling of the up-drift Rangitaiki Plains embayment which was essentially completed soon after the time of the Taupo Pumice eruption (AS 131). Over the last 2,000 years Ohope spit has accreted laterally eastwards at an average rate of about 3 m/year, Ohiwa spit has concomitantly eroded, and there has been accelerated infilling of Ohiwa Harbor. (41 refs)

Riepma, H. W. 1987. Topographically induced tidal vorticity in a shallow homogeneous sea area. (See complete entry in Section VIII.)

Rinaldo, A., and Putti, M. 1987. On tide-induced residual transport in schematic expansion. *Excerpta* 2:119-134.

This paper addresses the problem of computing residual circulation fields proper to tidal expansions both from an Eulerian and a Lagrangian viewpoint. The relevance of the problem lies in the need of establishing a reliable hydrodynamic description to the net convection over the tidal cycle which is the most significant factor whenever the impact is sought of long-term transport phenomena of conservative or slowly decaying tracers. It is concluded that caution should be taken in interpreting numerical results for they might be affected by severe limitations. The basis is then given to a probabilistic approach in the search for a dynamics operating at the higher scale of the whole expansion, with a view to the possible failure of the description of intertidal dispersion processes through Fick-type transport equations. (22 refs)

Roberts, P. J. W. 1980. Ocean outfall dilution: Effects of currents. (See complete entry in Section IV.)

Robinson, I. S. 1981. Tidal vorticity and residual circulation. *Deep-Sea Research* 28A(3):195-212.

Circulatory residuals, generated by the nonlinear interaction of tidal oscillatory flow and topography, are studied by examining the advection of the vorticity of the tidal flow. The time-histories of the vorticity of individual fluid elements are obtained from a simple Lagrangian model and used to obtain the Eulerian spatial distribution of residual vorticity. Different vorticity generating mechanisms are identified, and typical magnitudes and spatial scales of the residual circulation associated with them are tabulated. The possibility of thus estimating the magnitude and extent of residual flows generated by topographic features is illustrated by considering the example of the Hurd Deep in the English Channel. The implications of the results for the numerical modelling of shelf seas are considered. (8 refs)

Saiki, M., and Yanagino, T. 1984. Characteristics of the tidal current deduced from the GEK data in the eastern China Sea. (See complete entry in Section VIII.)

Sauvel, J. 1982. The tidal dynamics of the western North Sea. (See complete entry in Section VI.)

Scheffner, N. W. 1985. Investigation of tidally induced turbulent flow. (See complete entry in Section VI.)

Schmalz, R. A., Jr. 1983. Joint probability method in Barrier Island systems. *Journal of Waterway, Port, Coastal and Ocean Engineering,* ASCE, 109(2):222-235.

The joint probability method is modified to extend its application to flood level frequency determination for barrier island systems. The method developed accounts for the physical mechanism of barrier overtopping and is more economical than a direct statistical approach. The method involves an investigation of the dependency of hurricane surge at locations at and behind the barrier island chain on central pressure depression as well as the dependency of total stilled water elevation on astronomic tide and hurricane surge. To complete the method, a convolution approach for combining astronomical tide and hurricane surge consistent with overtopping and valid for large tidal ranges is presented. (16 refs)

Schmalz, R. A., Jr. 1985. User guide for WIFM-SAL: A two-dimension vertically integrated, time-varying estuarine transport model. (See complete entry in Section VI.)

†**Schomaker, C. W.** 1983. A model for tidal circulation adapted to Monterey Bay, California. (See complete entry in Section VI.)

Schroeder, W. W., Huh, O. K., Rouse, L. J., Jr., and Wiseman, W. J., Jr. 1985. Satellite observations of the circulation east of the Mississippi Delta: Cold-air outbreak conditions. *Remote Sensing of Environment* 18(1):49-58.

Examination of 12 years of Landsat multispectral scanner images shows a recurrent pattern of westward flow immediately south of the Mississippi-Alabama barrier islands under northerly winds. Such flow patterns are also seen under similar conditions in imagery from the Advanced Very High Resolution Radiometer (AVHRR) of the National Oceanic and Atmospheric Administration (NOAA)-series satellites. The flow enters Chandeleur Sound between Ship Island and the northern end of the Chandeleur Islands. It appears to be driven by northerly winds, which force water south through the Chandeleur-Breton Sound, drawing water in from the shelf region south of the Mississippi-Alabama barrier islands. These observations on circulation can be simply explained assuming linear dynamics. These two operational satellite systems are accumulating valuable records of coastal circulation patterns under clear-sky conditions. (15 refs)

Schubel, J. R., and Carter, H. H. 1984. The estuary as a filter for fine-grained suspended sediment. (See complete entry in Section II.)

Schubel, J. R., and Kennedy, V. S. 1984. The estuary as a filter: An introduction. (See complete entry in Section II.)

Seabergh, W. C. 1976. Improvements for Masonboro Inlet, North Carolina. (See complete entry in Section V.)

Seabergh, W. C. 1985. Los Angeles and Long Beach Harbors model study; Deep-draft dry bulk export terminal, alternative No. 6: Resonant response and tidal circulation studies. Miscellaneous Paper CERC-85-8. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Studies to determine the effect of the proposed Deep-Draft Dry Bulk Export Terminal, Alternative No. 6, on tidal circulation and harbor resonance in Los Angeles and Long Beach Harbors were conducted. The plan included a total of 448 acres of landfill in Los Angeles Harbor and dredging a navigation channel and maneuvering area. The effect of the proposed plan on tidal circulation was studied using an implicit-finite difference scheme numerical model with a two-dimensional depth-averaged formulation of the hydrodynamic equations. Tidal circulation was simulated for 70-hr sequences of spring, mean, and neap tides for existing and proposed plan conditions. Tidal elevations, velocities, discharges, flow volumes, net flow volumes, and dye concentrations were examined throughout the harbors. Only very slight changes occurred in flow distribution through the three main entrances to the harbors. Net easterly circulation in the outer harbor was reduced 21 to 24 percent. Net circulation in the inner harbor (Main Channel and Cerritos Channel) was reversed from the existing westerly flow to a net easterly flow of greater magnitude than for existing conditions, providing improved flushing of the inner harbor. Dye tests indicated no change in concentration in the shallow-water habitat for the plan when compared with existing conditions. Harbor resonance for the plan was examined with a 1:400 horizontal, 1:100 vertical scale model of Los Angeles and Long Beach Harbors, and the results were compared with resonant response for existing conditions. Wave periods ranging from 15 to 400 sec were tested. The

study produced results showing wave height amplification factors at 46 locations throughout the harbors. Testing indicated that for the proposed terminal locations along the island landfill and on Terminal Island, the resonant peaks were relatively low. The 185-sec-period wave produced the greatest wave height amplification of 5.1, but only at one location along Terminal Island. A 330-sec wave produced the only significant wave amplification (5.4) on the outer (or south) face of the island landfill. No significant resonant peaks were created at other locations throughout the harbors due to the plan except for a few very long periods (320 sec) at only a few locations. Some of the larger resonant peaks for existing conditions were reduced. (11 refs)

Seim, H. E., Kjerfve, B., and Sneed, J. E. 1987. Tides of Mississippi Sound and the adjacent continental shelf. (See complete entry in Section VIII.)

Sengupta, S., Miller, H. P., and Lee, S. S. 1981. Effect of open boundary condition on numerical simulation of three-dimensional hydrothermal behavior of Biscayne Bay, Florida. (See complete entry in Section VI.)

Sha, L. P. 1989. Sand transport patterns in the ebb-tidal delta off Texel Inlet, Wadden Sea, The Netherlands. (See complete entry in Section II.)

Sharaf El Din, S. H. 1977. Effect of the Aswan High Dam on the Nile flood and on the estuarine and coastal circulation pattern along the Mediterranean Egyptian coast. (See complete entry in Section II.)

Sheng, H., and Xiu-juan, Z. 1986. The classification and process characteristics of estuaries in China. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:507-516. University, MS: University of Mississippi.

This paper is based on the observed data of twenty navigable estuaries in China, with overall consideration and comprehensive analysis of data. The twenty estuaries can be classified into four types: sea phase estuaries of well mixing type; sea phase estuaries of partial mixing type; land and sea phase estuaries of partial mixing type; and land phase estuaries of weakly mixing type. For different types of estuaries, not only their plane configurations and longitudinal slopes are different, but also their fluvial process characteristics. (6 refs)

Sheng, Y. P. 1986. Numerical modeling of coastal and estuarine processes using boundary-fitted grids. (See complete entry in Section VI.)

Sheng, Y. P. 1989. Validation and intercomparison of three-dimensional numerical models of estuarine and lake hydrodynamics. (See complete entry in Section VI.)

Sheng, Y. P., and Butler, H. L. 1982. A three-dimensional numerical model of coastal, estuarine, and lake currents. (See complete entry in Section VI.)

Sherwin, T. J. 1988. Analysis of an internal tide observed on the Malin Shelf, north of Ireland. *Journal of Physical Oceanography* 18(7):1035-1050.

Evidence of an internal tide on the eastern side of the Rockall Trough is derived from recording current meters and thermistor chains sited at the edge and near the center of the Malin Shelf. Although the barotropic tidal currents are small (M_2 is 0.13 m sec^{-1}), temperature contour plots revealed significant semidiurnal oscillations at both sites. From an analysis of the data it appears that there was a linear, predominantly mode-1, internal tide which was coherent with the barotropic tide over the spring-neap cycle and which had a mean energy of 452 J m^{-2} at the shelf edge. The onshore flux (estimated to be 104 W m^{-1}) was about twice that predicted by the Baines model for subcritical slopes, but in view of the simplifications that are made, the comparison is considered reasonable. For the model to be applicable, most of the energy must be generated in the deep water of the Rockall Trough, propagating eastward over a marginally subcritical slope and onto the shelf. The energy dissipated at about 10^{-3} W m^{-2} (with an *e*-fold decay length of about 85 km) between the two stations. A number of possible sinks are examined, and it is concluded that much of the energy must be lost through overturning due to local Richardson number instabilities. It is suggested that the dissipation rate is sufficient to cause internal mixing of the summer thermocline, and that the mixing power of the internal tide on the outer shelf is greater than that of the barotropic tide. (33 refs)

Shideler, G. L. 1984. Suspended sediment responses in a wind-dominated estuary of the Texas Gulf Coast. (See complete entry in Section II.)

Smith, L. H., and Cheng, R. T. 1987. Tidal and tidally averaged circulation characteristics of Suisun Bay, California. (See complete entry in Section VI.)

Smith, P. E., ed. 1982. *Proceedings of the conference applying research to hydraulic practice,* 17-20 August 1982, Jackson, MS. New York: ASCE.

Contents by Sessions: Drop structures; Turbulence models in hydraulics computations I and II; Small hydro design innovations and applications I and II; New spillway concepts; Hydraulics of large rivers; Jets and mixing; small hydro case histories I, II, and III; Hydraulics of floods I and II; Scour by free-falling jets; Design and performance of reversible flow trash racks I and II; The energy/power approach to sediment transport phenomena; Metrication in water resources; Modeling of hydraulic systems I and II; Tidal hydraulics; Sediment transport I and II; Verification of models of hydrologic transport and dispersion I and II; Hydraulic transients: Numerical procedures; Lake Erie model studies; Effective use of tidal hydraulics measurements; Control of water quality in reservoirs and releases; Hydraulics of tidal inlets.

Snyder, R. L., Sidjabat, M., and Filloux, J. H. 1979. A study of tides, setup and bottom friction in a shallow semi-enclosed basin; Part II: Tidal model and comparison with data. (See complete entry in Section VI.)

Song, W., Yoo, D., and Dyer, K. R. 1983. Sediment distribution, circulation and provenance in a macrotidal bay: Garolim Bay, Korea. (See complete entry in Section II.)

†Spaulding, M. L., and Gordon, R. B. 1982. A nested numerical tidal model of the southern New England Bight. (See complete entry in Section VI.)

Stacey, M. W. 1985. Some aspects of the internal tide in Knight Inlet, British Columbia. *Journal of Physical Oceanography* 15(12):1652-1661.

The interaction of the tides with the sill of Knight Inlet, a fjord located on the coast of British Columbia, is investigated. The seasonal variation in the stratification of the inlet causes a large seasonal variation in the power withdrawn from the barotropic tide. Usually, most of the withdrawn tidal power can be accounted for by a simple model of the internal tide. Obviously, the modal composition of the internal tide in an inlet is a function both of the inlet topography and the stratification. In particular, when there is a thin but distinct surface layer, caused possibly by river runoff, both first and second modes can transport significant amounts of energy away from the sill. When this is the case, the surface layer as well as the underlying stratification must be taken into account when calculating the amount of energy being transported by the internal tide. (7 refs)

†Staples, D. J. 1983. Environmental monitoring: Climate of Karumba and hydrology of the Norman River Estuary, southeast Gulf of Carpentaria. (See complete entry in Section VII.)

Stelling, G. S., Wiersma, A. K., and Willemse, B. T. M. 1986. Practical aspects of accurate tidal computations. (See complete entry in Section VI.)

Sternberg, R. W. 1979. Bottom-current measurements and circulation in Western Port, Victoria. (See complete entry in Section VIII.)

Stevenson, J. C., Ward, L. G., and Kearney, M. S. 1988. Sediment transport and trapping in marsh systems: Implications of tidal flux studies. (See complete entry in Section II.)

Stride, A. H., and Chesterman, W. D. 1973. Sedimentation by nontidal currents around northern Denmark. (See complete entry in Section II.)

Su, J., and Wang, K. 1986. The suspended sediment balance in Changjian Estuary. (See complete entry in Section II.)

†Summers, L., and Clifford, J. E. 1981. Maritime investigations for artificial islands. In *Proceedings, international conference on industrial islands,* 17-19 November 1981, London, UK, Paper C250/81:31-37. Bury St. Edmunds, UK: Mechanical Engineering Publications Ltd.

This paper describes the parameters such as wave height, wave direction, tides and tidal fluctuations, currents, winds, and seabed contours which need to be investigated when designing artificial offshore islands. Desirable environmental studies are also described, and the required data collection and analysis for all investigations discussed. A flowchart for the analysis and modelling is presented.

†Swift, M. R., and Brown, W. S. 1983. Distribution of tidal bottom stress in a New Hampshire estuary. Durham, New Hampshire University.

Estimates of area-averaged, total bottom stress are made for four channel segments of the Great Bay Estuary, New Hampshire. Sea level and current measurements are used to estimate pressure gradient

and acceleration terms in the equation of motion, while the equation of motion itself is used to infer the remaining stress term. Dynamic terms, bottom stress values, friction coefficients, and energy dissipation rates are estimated for each site. To aid in interpreting the results, sea level and current data are subject to a harmonic analysis to determine the tidal constituents.

†**Taft, J. L., and Wang, D.-P.** 1982. Vertical mixing and nutrient transport in the Chesapeake Bay. (See complete entry in Section II.)

Tang, Y., and Tee, K.-T. 1987. Effects of mean and tidal current interaction on the tidally induced residual current. (See complete entry in Section VI.)

Tee, K.-T. 1985. Depth-dependent studies of tidally induced residual currents on the sides of Georges Bank. (See complete entry in Section VI.)

Tee, K.-T. 1981. A three-dimensional model for tidal and residual currents in bays. (See complete entry in Section VI.)

Thabet, R. A. H., and Vlasblom, H. P. L. 1985. Forecasting current velocity on routine basis. In *International conference on numerical and hydraulic modelling of ports and harbours,* 23-25 April 1985, Birmingham, England, ed. J. H. Pounsford, 131-138 Cranfield, Bedford, England: British Hydromechanics Research Association.

A current forecast system has been set up as an aid to executional operations of the storm surge barrier in the mouth of the Oosterschelde Estuary. The system makes use of deterministic models (hydraulic and mathematical) and/or time-series analysis techniques. A short description of the system is given, as well as an account for its performance. The application of Frequency Response Functions to forecast (tidal) current velocity is discussed. (5 refs)

Thomas, W. A., and McAnally, W. H., Jr. 1985. User's manual for the generalized computer program system: Open-channel flow and sedimentation, TABS-2; main text. (See complete entry in Section VI.)

Thomson, J. D., and Godrey, J. S. 1985. Circulation dynamics in the Derwent Estuary. (See complete entry in Section III.)

Thomson, R. E., and Wolanski, E. J. 1984. Tidal period upwelling within Raine Island entrance, Great Barrier Reef. (See complete entry in Section VIII.)

Thouvenin, B., and Salomon, J.-C. 1984. Three-dimensional model of circulation and dispersion in a tidal coastal area (Modèle tridimensionnel de circulation et de dispersion en zone côtière à marée). (See complete entry in Section VI.)

Trump, C. L., and Burt, W. V. 1981. Wintertime current meter measurements from the East China Sea. (See complete entry in Section VIII.)

Tunnicliffe, V., and Syvitski, J. P. M. 1983. Corals move boulders: An unusual mechanism of sediment transport. (See complete entry in Section II.)

Vemulakonda, S. R., Swain, A., Houston, J. R., Farrar, P. D., Chou, L. W., and Ebersole, B. A. 1985. Coastal and inlet processes numerical modeling system for Oregon Inlet, North Carolina. (See complete entry in Section VI.)

Vongvisessomjai, S., and Charuskumchornkul, S. 1989. Boundary conditions of tidal model at river mouth. (See complete entry in Section VI.)

Vongvisessomjai, S., and Rojanakamthorn, S. 1989. Interaction of tide and river flow. *Journal of Waterway, Port, Coastal, and Ocean Engineering,* ASCE, 115(1):86-104.

Studies on the interaction of tide and river flow are scarce, while studies on the simplified characteristics of tides in canals and gulfs are common. This study employs the perturbation method to solve analytically the interaction of tides and river flow, taking into account the nonlinear convective inertia and bottom friction. Appropriate characteristics of the interaction obtained from an analysis of five records along a river are used in the derivation and verification. The study finds that the interaction of the tide and the river flow is well described by the analytical solution for implicit doppler shift. Exclusion of the convective term yields an underestimation of the tidal damping. The river flow raises the mean water level but damps the tide and reduces its celerity. The raising of the mean water level during a high discharge is more than the damping of the tide, causing flooding at high water level. Application of the analytical solutions for any value of the river flow requires

only the bottom condition of the river, which is found to be smooth for the large alluvial river. (11 refs)

†**Voorhis, A. D., Epifanio, C. E., Maurer, D., Dittel, A. I., and Vargas, J. A.** 1983. The estuarine character of the Gulf of Nicoya, an embayment on the Pacific Coast of Central America. (See complete entry in Section VIII.)

†**Walton, R., Shubinski, R. P., and Aldrich, J. A.** 1982. A three-dimensional circulation model for Chesapeake Bay. (See complete entry in Section VI.)

Wang, D.-P., and Elliott, A. J. 1978. Non-tidal variability in the Chesapeake Bay and Potomac River: Evidence for non-local forcing. *Journal of Physical Oceanography* 8(2):225-232.

Nontidal variability in the Chesapeake Bay and Potomac River, and its relation to atmospheric forcing, is examined from 2-month sea level and bottom current measurements. The dominant sea level fluctuations in the bay had a period of 20 days, and were the result of upbay propagation of coastal sea level fluctuations generated by the alongshore winds. Consequently, water was driven out of the bay by the northward/upbay wind and driven into the bay by the southward/downbay wind, through the coastal Ekman flux. There were also large sea level fluctuations at periods of 5 and 2.5 days. The 5-day fluctuations were driven by both the coastal sea level changes and the local lateral winds (Ekman effect). The 2.5-day fluctuations were seiche oscillations driven by the local longitudinal winds. In the Potomac River, the sea level fluctuations were induced nonlocally by motions in the bay; the associated volume fluxes appeared to have been confined to the upper layer. The near-bottom currents were mainly driven by the surface slopes which were also set up nonlocally, by the longitudinal wind over the bay. In general, the near-bottom current and sea level/ volume flux fluctuations were not coherent. A notable exception, however, was found for the 2.5-day fluctuations which were vertically coherent and showed significant upward phase propagation. Because of the significance of nonlocal forcing, an adequate model for the nontidal estuarine circulation would need to include the effects of interaction with the adjacent larger estuary or the coastal ocean. Also, site-specific experiments should be complemented by far-field measurements to determine non-local conditions. (8 refs)

Wang, J. D., Blumberg, A. F., Butler, H. L., and Hamilton, P. 1990. Transport prediction in partially stratified water. (See complete entry in Section VI).

Wang, S. Y., Shen, H. W., and Ding, L. Z., ed. 1986. *River sedimentation.* (See complete entry in Section II.)

Ward, P. R. B. 1979. Seiches, tides, and wind set-up on Lake Kariba. (See complete entry in Section VIII.)

†**Webb, A. J.** 1985. The propagation of the internal tide around a bend in Knight Inlet, B. C. Ph.D. diss., The University of British Columbia, Vancouver, BC, Canada.

This study seeks to answer the question, "How much of the internal tide propagation up Knight Inlet, B.C. is reflected by a right-angled bend?" The internal tide in Knight Inlet is generated by the interaction of the barotropic tide with a shallow sill seaward of the bend. It then propagates in both directions as a travelling Kelvin wave. The up-inlet propagating wave then encounters the bend, where some of it may be reflected. The theoretical study investigates the propagation of a Kelvin wave around a bend in a channel. The solution of the linearized long wave equations is expressed as a truncated series of cross-channel modes in each of three regions. The solution is matched across the two common boundaries. The "rectangular bend" gives unsatisfactory results because of a singularity in the velocity field at the sharp inside corner. However, the "annular bend" gives good results. The bend acts as a diffraction grating, with total transmission for certain bend angles and "lobes" of high reflection for intermediate angles. For the parameters corresponding to the M_2 internal tide in Knight Inlet, the energy flux reflection coefficient is very small, much less than 1 percent. The method of solution breaks down inexplicably for diurnal tides. The observational study is based upon 2-1/3 months of cyclesonde current meter data from four stations taken during the summers of 1981 and 1983. The vertical profiles of amplitude and phase of the M_2 constituent of longitudinal velocity and density fluctuations are decomposed into a truncated series of normal modes for waves propagating both up-inlet and down-inlet. At the two stations up-inlet of the sill, acceptable fits can be obtained using only two up-inlet propagating modes, indicating that the data are compatible with the low reflection found in the theoretical study. The

results indicate that only 30-50 percent of the power removed from the barotropic tide is being fed into the internal tide in the summer.

Weishar, L. L., and Fields, M. L. 1985. Annotated bibliography of sediment transport occurring over ebb-tidal deltas. (See complete entry in Section II.)

West, J. R., and Mangat, J. S. 1986. The determination and prediction of longitudinal dispersion coefficients in a narrow, shallow estuary. (See complete entry in Section VIII.)

Westerink, J. J., Stolzenbach, K. D., and Connor, J. R. 1989. General spectral computations of the nonlinear shallow water tidal interactions within the Bight of Abaco. (See complete entry in Section VI.)

Weydert, P., and Weydert, O. 1982. Sedimentological study of the mouth of the Gabon River Estuary. (Etude sedimentologique de l'embouchure de L'Estuaire du Gabon). (See complete entry in Section II.)

Williams, A. 1986. Small harbour problems in Southern China. (See complete entry in Section II.)

†**Williams, R. G.** 1985. The internal tide off Southern California. Ph.D. diss., University of California, San Diego, CA.

The internal tide may well form an important link in the chain of events between the forcing of the surface tide and the eventual dissipation of internal waves by viscous forces. Two issues related to this chain of events are addressed. One is the directionality of the internal tide off the coast of California and the other is the widespread occurrence of semidiurnal tidal harmonics in internal wave spectra. It is commonly accepted that the internal tide derives its energy from the forcing of isopycnal surfaces over topographic features by the surface tide. Accordingly, steep continental slopes like the Patton escarpment should be important generation regions. The directionality of the internal tide off California and hence the importance of the Patton escarpment as a source are assessed by analyzing data collected by the R/P FLIP. The results indicate that the direction of propagation of the internal tide is variable and that the majority of its energy does not appear to originate at the escarpment. Strong peaks at the harmonics of the semidiurnal frequency have been observed in many internal wave spectra. At issue is whether these harmonics are (a) artifacts of the measurement technique, (b) the signature of free waves present at those frequencies, or (c) the manifestation of local nonlinearity of the internal tide. Evidence suggests that (a) is not an important effect. In an attempt to differentiate between (b) and (c) a bispectral analysis of a set of isopycnals was performed. The resulting bicoherence (normalized bispectrum) values indicate that there is a significant degree of quadratic coupling between the internal tide and its harmonics. The observations of wave shape are consistent with Thorpe's theoretical model for the shape of finite amplitude internal waves in a continuously stratified fluid. However, the biphase values indicate that the shape of the internal tide is vertically asymmetric, unlike the symmetric shapes predicted by the model. The observed strong nonlinearity of the internal tide indicates that it is possibly an important source for the internal wave continuum, contradicting a recent claim which is based on weak nonlinear resonant interaction theory.

Wilson, P. R. 1985. Tidal studies in the One Tree Island Lagoon. *Australian Journal of Marine and Freshwater Research* 36(2):139-156.

The response of the water levels in the lagoon of One Tree Island to the external tides has been studied in two series of observations in May-June 1982 and in August 1983. The tide at the eastern end of the lagoon consistently reaches maximum height 20 min after the external maximum at this point and there is evidence that the internal maximum level is 2 cm higher than the external level. The response at several points inside the lagoon is the same. Studies of the velocity profiles with height and of the mean velocity at one point on the inner edge of the reef on the leeward side show that the tide "turns," i.e., outflow begins, regularly 45 min before the local high water. If the outflow is wind-assisted, this effect is even more pronounced. The flow across the reef is by no means uniform, however, and at points on the windward side of the reef the inflow may continue for ~2 hr after high water. The water-surface gradient across the reef was monitored at one location on the leeward side. Under light to moderate wind conditions, the velocity of the flow across the reef corresponded closely to this gradient, suggesting that inertial effects are small compared with those arising from turbulent or eddy viscosity. These results are compared with theoretical models for the tidal levels within an idealized circular lagoon surrounded by an annular reef. Some of the features of the observed tides can be reproduced using a simple axisymmetric model for which the effective viscosity is of the order of 10^{-2}-10^{-3} m^2 sec^{-1}. However, the windward-leeward asymmetry in the flow velocities

requires the inclusion of an asymmetric forcing term representing surface wind stresses on waves breaking on the windward margin of the reef. By a suitable choice of this term, it is shown that all the features of the observed tides can be qualitatively reproduced by the model. (7 refs)

Wolanski, E. 1983. Tides on the northern Great Barrier Reef continental shelf. (See complete entry in Section VIII.)

Wong, K.-C. 1985. On the effects of spatial variation in amplitude and phase of the oscillatory tidal currents on the residual Lagrangian drifts. *Water Resources Research* 21(5):769-774.

The basic behaviors of residual Lagrangian drifts under the influence of oscillatory tidal currents with spatial variations in amplitude and phase are examined analytically for relatively simple Eulerian velocity fields. Intense residual Lagrangian drifts are shown to be generated by strong spatial velocity gradients, and the residual drifts at any given location are heavily dependent upon the initial release time relative to the phase of the tidal current. The presence of a relatively weak mean flow can interact with the tidal currents and produce significant modification of the residual drifts as well as their dependency on the initial conditions. Both the magnitude and the direction of the mean flow are important in affecting the dependency of the residual drift estimates on the initial conditions. (5 refs)

Wong, K.-C. 1987. Tidal and subtidal variability in Delaware's inland bays. *Journal of Physical Oceanography* 17(3):413-422.

Sea level observations made during a 3-month period in late 1984 at four stations in and near Delaware's inland bays are used for the examination of tidal and subtidal variability in the bays. Five tidal constituents are found to be active in the bays, with M_2 being the most important one. The inland bays, with their narrow inlets and shallow depths, behave like low-pass filters for oceanic disturbances propagating into the interior of the bays. Overall, tidal variance decreases sharply inside the bays, with the semidiurnal tides suffering significantly higher attenuation than the diurnal tides. At subtidal frequencies, sea level fluctuations in the interior of the bays are primarily forced by coastal sea level fluctuations generated by atmospheric forcing on the adjacent shelf. Local wind forcing within the bays appears to play only a secondary role in modifying the coastally forced sea level. The active subtidal sea level fluctuations induced by the bay-shelf coupling effect experience no appreciable attenuation within the bays. As a consequence, sea level variance at subtidal frequencies is even greater than that at tidal frequencies in one of the inland bays. (19 refs)

Wong, K.-C., and Garvine, R. W. 1984. Observations of wind-induced, subtidal variability in the Delaware Estuary. *Journal of Geophysical Research* 89(C6):10,589-10,597.

Sea level and current observations made in the Delaware estuary during autumn of 1982 were examined for evidence of wind-forced subtidal variability. The large subtidal sea level fluctuations at the mouth of the Delaware were found to be forced primarily by the wind stress component over the continental shelf nearly parallel to shore, indicating coastal Ekman transport to the right of the wind. Local wind forcing within the estuary is shown to be insignificant. The subtidal sea level in the interior of the estuary was found to be driven by the wind through a combination of two remote forcing mechanisms: one acting at the mouth of the Delaware through direct estuary-shelf coupling and a second acting locally over the Chesapeake Bay and being transmitted from the upper Chesapeake through the Chesapeake and Delaware Canal, which links the two estuaries. In the upper Delaware estuary predominantly barotropic subtidal current fluctuations superimposed on a much weaker two-layer gravitational circulation were found. These current fluctuations were produced primarily by the local subtidal surface slope generated by the difference between the two remote forcing mechanisms. The evidence strongly suggests that the Chesapeake and Delaware Canal plays a critical role in the subtidal circulation of the Delaware estuary. (14 refs)

Wood, P. C., and Abel, R. 1986. Inputs into the North Sea and their effects. (See complete entry in Section IV.)

†Wu, T.-S. 1987. Direct computation of tidal circulation in harbors. (See complete entry in Section VI.)

Wu, T. S., and Janowitz, G. S. 1989. An analytical solution to verify a nonlinear tidal circulation model. (See complete entry in Section VI.)

Young, W. R. 1983. Topographic rectification of tidal currents. *Journal of Physical Oceanography* 13(4):716-721.

The rectification of oscillatory tidal currents on the sloping sides of a low submarine bank is discussed using the moment method. This method has been previously used in shear dispersion studies where it is used to analyze the advection-diffusion equation. In the present problem it is applied to the barotropic potential vorticity equation linearized about an oscillatory, spatially uniform tidal velocity. To apply the method it is necessary to assume that the topography produces only a small change in depth. The method economically provides the most important qualitative properties (e.g., transport, location and width) of the time-averaged current. These results are obtained without making a harmonic truncation. They can then be used to assess the accuracy of the harmonic truncation approximation used by other authors. It is shown that harmonic truncation correctly predicts the transport and location of the rectified current when the bank is low. However, if the width of the bank is much less than a tidal excursion distance, harmonic truncation may give a very mistaken impression of the width of the rectified current. Finally, lateral vorticity diffusion is included in the moment calculation. It is shown that this dissipative process does not change the transport or location of the rectified current. It does however increase its width. (12 refs)

†**Zaitlin, B. A.** 1987. Sedimentology of the Cobequid Bay - Salmon River Estuary, Bay of Fundy, Canada. (See complete entry in Section II.)

Zarillo, G. A. 1982. Stability of bedforms in a tidal environment. *Marine Geology* 48(3/4):337-351.

Large-scale bed forms were investigated in the Duplin River, a tidal estuary in Sapelo Island, Georgia. Two distinct forms were discerned: megaripples, also called dunes (4- to 15-m wavelength and 10-75 cm high), and sand waves (15- to 45-m wavelengths and 85-130 cm high). The sand waves existed in megarippled and smooth-crested forms. The large-scale bed forms maintained an ebb-oriented geometry through both ebb and flood parts of the tidal cycle. Bed forms were in equilibrium with peak tidal flow, and ebb orientation was the direct result of large pressure gradients and bed shear values which developed during the ebb. Bed form heights were dependent on flow power, shear velocity, water depth, and sediment grain size, but were not dependent on mean flow velocity. The significant parameters were used to construct bivariate plots showing separate stability fields of sand waves and megaripples. The magaripples formed at smaller flow depths and lower flow power values than sand waves. The megarippled sand waves formed in areas of coarser sand, and smooth-crested sand waves in finer sands. (15 refs)

Zetler, B. D., and Flick, R. E. 1985. Predicted extreme high tides for California: 1983-2000. *Journal of Waterway, Port, Coastal and Ocean Engineering,* ASCE, 111(4):758-765.

The combination of high tides and storm-induced waves were devastating to the coast of California during the winter of 1982-1983. As property owners began to repair the damage and to consider building various protective structures, questions arose as to how high the tides would be in the future, whether a new era in Pacific weather was being entered, and if sea level was really rising, how fast. Of all these factors, the only one amenable to skillful scientific prediction is the future times and heights of the astronomical tides. Studies of sea level trends depend primarily on accumulated tide gage data over many years. There is considerable variability from year to year at any station; there are significant regional differences as well. Objective analysis suggests an average global rise in sea level over the past century of about 0.5 ft (0.15 m). Projections of global sea level rise for the next century generally forecast a much higher rise due to accelerated melting of polar glaciers as well as increased warming of ocean surface layers. Both may be related to increased amounts of carbon dioxide in the atmosphere. The National Ocean Service, which prepares the official US tide predictions, periodically updates its datum to conform to values observed over a 19-year period. The predictions used in this study from 1985 on are based on a new 1960-1978 epoch. However, predicted tides appearing herein may be as much as several tenths of a foot (0.03-0.09 m) lower than they should be by the end of the 1983-2000 period, depending on the actual sea level rise after 1980. The predictions provide a measure of reassurance to those concerned with California's coastal zone and should be useful in the design of protective structures and other coastal engineering projects. (6 refs)

Zetler, B. D., and Flick, R. E. 1985. Predicted extreme high tides for mixed-tide regimes. *Journal of Physical Oceanography* 15(3):357-359.

There are a number of published studies of the astronomical conditions prevailing when extreme high tides are predicted, but usually these are directed toward tidal regimes that are dominantly semidiurnal. The published criteria are found to be inadequate for mixed regimes (diurnal tides roughly the same order

SECTION II. SEDIMENTATION

Sources, identification, transportation, deposition, flocculation, and physical and chemical properties of sediment found in tidal waterways. The upland river is excluded unless specifically concerned as a source and agent of transport of tidal sediment.

Aggerholm, D. A. 1989. Sediment regulation in Puget Sound. In *Dredging: Technology, environmental, mining; proceedings of WODCON XII,* 2-5 May 1989, Orlando, Florida, 100-109. Irvine, CA: World Dredging Mining and Construction.

The Puget Sound Water Quality Authority's Management Plan contains an extremely ambitious program for sediment regulation in Puget Sound. The plan, which carries the considerable power of the Authority, specifies a zero tolerance goal for all sediments in Puget Sound and directs state and local agencies to develop and implement standards, criteria, and procedures relating to all aspects of sediment control and management. Washington's ports and many others are concerned about the manner in which the program is proceeding. In particular, the levels of environmental protection being established are viewed as unrealistic and unachievable, especially in urban industrial areas. These interests fear that the program could result in severe economic and social disruption for some industries and communities which depend on dredging.

†**Aiyesimoju, K. O.** 1986. Numerical prediction of transient water quality in estuarine/river networks. (See complete entry in Section VI.)

Al-Bakri, D. 1986. Provenance of the sediments in the Humber Estuary and the adjacent coasts, eastern England. *Marine Geology* 72(1/2):171-186.

A study of the modern conditions in the Humber Estuary and the adjacent coasts reveals an area of severe erosion on the Holderness coast counterbalanced by deposition inside the Spurn Head and the Humber Estuary. There have been much discussion and controversy regarding the movement and destination of the eroded material and whether the sand banks in the estuary and masses of sand along its southern flank are derived entirely from the Holderness cliffs or other sources, such as the Humber River and the floor of the North Sea. In the present study a heavy-mineral investigation was carried out in an attempt to understand the provenance of the sediments deposited in the Humber Estuary and its southern flank and to define the relative importance of the Holderness cliffs as a source of these sediments. A heavy-mineral association marked by the predominance of garnet-opaques-amphiboles-pyroxenes and epidotes was found to characterize the sediments in all parts of the study area. Differences in relative abundance of the common heavy minerals were noticed but no fundamental differences exist and no new species were introduced. Such difference was attributed to the effect of selective sorting of the detrital grains which are governed by their shape and specific gravity. The main conclusion of the study is that material transported to the study area by land drainage system or moved shoreward from the floor of the North Sea by waves and currents contributes nothing to the sand fraction of the study area and probably very little of the fine fraction (silt and clay), while material eroded from the Holderness cliffs represents the main source of the sediments in the estuary and its southern flank. (19 refs)

Allen, J. R. L. 1987. Coal dust in the Severn Estuary, southwestern UK. (See complete entry in Section IV.)

Allen J. R. L. 1982. Simple models for the shape and symmetry of tidal sand waves: (3) Dynamically stable asymmetrical equilibrium forms without flow separation. (See complete entry in Section VI.)

Allen, J. R. L., and Rae, J. E. 1988. Vertical saltmarsh accretion since the Roman period in the Severn Estuary, southwest Britain. (See complete entry in Section VIII.)

Amano, K., and Fukushima, T. 1988. On the longitudinal and vertical changes in lake estuarine sediments. (See complete entry in Section IV.)

†**American Petroleum Institute.** 1986. Tidal area dispersant project: Fate and effects of chemically dispersed oil in the nearshore environment. (See complete entry in Section IV.)

Anderson, F. E., and Meyer, L. M. 1986. The interaction of tidal currents on a disturbed intertidal bottom with a resulting change in particulate matter quantity, texture and food quality. *Estuarine, Coastal and Shelf Science* 22(1):19-29.

The purpose of this investigation was to determine if clam digging had an effect on the suspended sediment texture and composition in the intertidal zone. Surface sediment and suspended particulate samples were collected prior to and after bottom perturbation similar to clam digging. The results indicated that the dug bottom sediments became coarser and contained lower amounts of organic matter. The coarser texture was due to increased winnowing on the "rough" bottom created in the digging process. Suspended sediment concentrations also increased after

perturbation, especially over finer textured areas. The resuspended particulates were well sorted with relatively low organic content. Resuspended bottom sediments contributed virtually no protein to the particulates brought in by the estuarine waters. Recovery rate both of the bottom sediments and the suspended particulates was slow, and seemed dependent on the microtopographic relief which could take weeks to months to return to normal. (31 refs)

Anderson, G. F. 1986. Silica, diatoms and a freshwater productivity maximum in Atlantic coastal plain estuaries, Chesapeake Bay. (See complete entry in Section III.)

Andrassy, C., and Herbich, J. B. 1988. Generation of resuspended sediment at the cutterhead. (See complete entry in Section V.)

Ashley, G. M., and Grizzle, R. E. 1988. Interactions between hydrodynamics, benthos and sedimentation in a tide-dominated coastal lagoon. *Marine Geology* 82(1/2):61-81.

Great Sound is a 6-km^2 shallow (average depth = 0.6 m) lagoon fringed by salt marsh and connected directly to the ocean by two large (5 and 10 km long) flood-dominated tidal channels which enter at opposite ends. The lagoon can be divided into three subenvironments: flood tidal delta and channel, transition area, and basin. Tidal deltas containing several distributary channels are deposited from expanding jet flow as tidal currents enter the lagoon. A physical process study (velocity profiles, salinity, temperature, suspended load and box cores) indicated that sedimentation patterns are determined by (a) proximity to the point sources of sediment, the tidal channels, (b) spatial changes in tidal current strength and abundance of benthic organisms (primarily sand-trapping macroalgae), (c) dispersion of particulates by tidal and wave-generated currents, and (d) post-depositional processes including bioturbation and resuspension by waves. Tidal currents ranged from U_{max} > 40 cm/sec (U_{*sec} = 4.0 cm/sec) in the tidal delta channels, to U_{max} < 20 cm/sec (U_{*max} = 2.6 cm/sec) in transition areas to U_{max} < 10 cm/sec (U_{*max} = 1.0 cm/sec) in basins. U_{max}, U_{*max} = maximum current velocity and maximum shear velocity, respectively. Typical suspended sediment loads were 10-50 mg/l near the bottom; however, sediment transport was enhanced by wind-generated waves (up to 0.5 m wave height) which eroded the bottom creating concentration spikes of greater than 300 mg/l. Bottom sediments ranged from well-sorted fine sand in most delta and channel areas to basins composed of 90 percent silt and clay. Factors affecting sediment supply, transportation, deposition, and resuspension interact in complex ways so that wide variability in the textural characteristics of deposited sediment occurs and no single factor (e.g., velocity) is well correlated with sediment characteristics. A conceptual model illustrating these spatial relations between hydrodynamics, benthos, and sedimentation in the Great Sound system was developed. The model should be useful in other tide-dominated coastal lagoons as a guide for design of benthic and sedimentary studies. (59 refs)

Ashley, G. M., and Zeff, M. L. 1988. Tidal channel classification for a low-mesotidal salt marsh. *Marine Geology* 82(1/2):17-32.

The 5-km-wide low-mesotidal (1.3-m mean tidal range) back-barrier system of southern New Jersey is a complex network of tidal channels, salt marsh, and lagoons. A 3-year study of the fair weather and storm flow and sediment dynamics within the tidal channel network revealed that the channels could be placed into two fundamental hydraulically based groups: through-flowing and dead-end. A classification for low-mesotidal tidal channels is proposed. The first group (through-flowing channels) acts as a conduit and is composed of two types with different functions, which either (a) connect the ocean to the lagoon, or (b) connect two tidal channels. The second group (branching dead-ending channels) terminates in the salt marsh. Each of the three types is distinct and can be distinguished by a set of physical and hydrodynamic characteristics. Their importance varies during the evolution of the back-barrier setting when the environment changes from predominantly open water to predominantly salt marsh. Through-flowing channels apparently have a more prominent role during early stages of salt marsh development, whereas dead-end channels become increasingly important with time and dominate in the late stages when little open water remains. (25 refs)

Badenhorst, P. 1986. Effect of dredging on estuarine environments, alternative disposal sites and dredging guidelines. (See complete entry in Section V.)

Baillie, P. W. 1986. Oxygenation of intertidal estuarine sediments by benthic microalgal photosynthesis. (See complete entry in Section VI.)

Baker, E. T. 1984. Patterns of suspended particle distribution and transport in a large fjordlike estuary. (See complete entry in Section I.)

Bale, A. J., Morris, A. W., and Howland, R. J. M. 1985. Seasonal sediment movement in the Tamar Estuary. *Oceanologica Acta* 8(1):1-6.

Seasonal movements of sediment in the Tamar Estuary have been estimated by recording variations in sediment levels at 30 sites evenly distributed along the length of the estuary through a 14-month period. A marked seasonal migration was observed in which sediment was gradually accumulated in the upper estuarine turbidity maximum zone during the spring and summer months. In winter, this sediment was redistributed into localized depositional sites in the mid-estuarine region. Regressions of sediment accumulation against riverflow indicate that internal cycling of sediment is primarily driven by changes in riverflow. Particle fluxes and the total amount of material involved in this seasonal migration have been calculated and the potential mobile sediment replacement time has been estimated. (23 refs)

Bales, J. D., and Holley, E. R. 1989. Sand transport in Texas tidal inlet. *Journal of Waterway, Port, Coastal, and Ocean Engineering,* ASCE, 115(4):427-443.

Rollover Pass is a man-made, artificially stabilized tidal inlet on the upper Gulf Coast of Texas. The magnitude of the net annual sand transport through the inlet was estimated: (a) as a percentage of the net longshore transport; (b) from excess beach erosion downdrift of the pass; and (c) from dredge material volumes for the Intracoastal Waterway landward of the inlet. Limited direct measurements of sand transport were also made. The excess beach erosion downdrift of the pass was between about 9,000 and 26,000 cu yd/year (6,700 and 20,000 m^3/year, which was in general agreement with the estimation of net annual sand transport calculated as a percentage of longshore transport. Net annual transport through the inlet estimated from extensive data on dredging rates was nearly an order of magnitude greater than estimates based on longshore transport and beach erosion. (16 refs)

Barthe, X., and Castaing, P. 1989. Theoretical study of the action of tidal currents and swell on the sediments of the continental shelf of the Bay of Biscay (Étude théorique de l'action des courants de marée et des houles sur les sédiments du plateau continental de Golfe de Gascogne). *Oceanologica Acta* 12(4):325-334 (In French).

From the study of hydrodynamic conditions (swell and currents) in the Bay of Biscay, details can be determined relating to the process and duration of the movement of sediments deposited on the continental shelf. Such theoretical data are obtained using *in situ* measurements and tables for the threshold of grain motion and the duration of sediment movement. The results demonstrate that the construction of the sedimentary forms observed on the continental shelf is a product of the combined action of swell and tidal currents. Under normal conditions, i.e., outside periods of strong gales, the tidal currents never in fact reach velocities sufficient to initiate the grain motion of the deposited sediments. This study shows that the sedimentary movements on the continental shelf of the Bay of Biscay have only a very limited annual duration, except close to the coastline. (35 refs)

Barwell, L. 1988. Dynamics of the Palmiet River mouth. (See complete entry in Section I.)

†**Basinski, T.** 1981. Tidal measurements of suspended sediment concentrations in the surf zone. In *Erosion and sediment transport measurement,* Proceedings of the Florence symposium, 22-26 June 1981, Florence, Italy, Publication No. 133, 137-150. Wallingford, Berkshire, England: International Association of Hydrological Sciences.

Three methods of measuring suspended sand concentrations were selected from existing techniques and field tests were carried out. These include a sand trap, a suction sampler and a radioactive probe. The problems of calibration were examined. Values and sources of error, integration times for the measurements, ranges of application and accuracy of the above devices were also determined.

Bassoullet, P., Djuwansah, R., Gouleau, D., and Marius, C. 1986. Hydrosedimentological processes and soils of the Bariot Estuary (South Kalimantan, Indonesia). *Oceanological Acta,* 9(3):217-226.

A pluridisciplinary study was carried out in the southeastern part of Kalimantan, Indonesia, in a deltaic area close to Banjarmasin town. Upstream from Banjarmasin, Barito River divides into two branches, one of which meets the Kapuas River slightly further to the west, to form the Kapuas Murung Estuary. This program is designed to increase knowledge about the physical and

sedimentological processes, physical and chemical properties of the soils, and hydrological and chemical parameters of the Barito Estuary. Barito Estuary was chosen for two main reasons. First, it constitutes an important waterway for the region, on which Banjarmasin Harbor is located, and second, the management of the sparsely occupied coastal areas is becoming a priority. The transmigration area of Tabunganen, close to the coast (with some saline intrusion problems), is significant in this connection. The study, some results of which are presented here, is not complete; this is especially due to a lack of data during the rainy season. But its aim is to provide the basis for any future complementary study. (9 refs)

Bedford, K. W. 1985. Selection of turbulence and mixing parameterizations for estuary water quality models. (See complete entry in Section VI.)

Berger, R. C., Jr., Heltzel, S. B., Athow, R. F., Jr., Richards, D. R., and Trawle, M. J. 1985. Norfolk Harbor and channels deepening study; Report 2, Sedimentation investigation; Chesapeake Bay hydraulic model investigation. Technical Report HL-83-13. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

This report presents the sedimentation findings from combined physical and numerical model tests (hybrid modeling) of deepening the approach channels to Norfolk and Newport News, Virginia. Because of the varying nature of shoaled material along the project navigation channel, the tests included two separate numerical sediment transport models, which were referred to as the Thimble Shoal model and the Elizabeth River model. The sediment along the Thimble Shoal portion of the navigation channel consists predominantly of non-cohesive material while the sediment along the Elizabeth River portion of the navigation project consists primarily of clays and silts. Sedimentation in a third portion of the overall project, referred to as the Atlantic Ocean Channel, was evaluated analytically without using a numerical sediment transport model. Based on sedimentation results from the Elizabeth River numerical model, the increase in shoaling caused by channel deepening as proposed will be 23 percent. The distribution of shoaled material will not be significantly altered, other than a slight increase in skewness toward the downstream end. Based on sedimentation results from the Thimble Shoal numerical model, the increase in shoaling caused by channel deepening as proposed will be about 20 percent. The distribution of shoaled material will be slightly altered in that both the upper and lower channel shoaling peaks which presently exist will tend to migrate even more toward the ends of the dredged channel. Based on the analytic analysis, the estimate of shoaling for the new Atlantic Ocean Channel is about 200,000 cu yd annually. (25 refs)

Bernard, P. C., Van Grieken, R. E., and Eisma, D. 1986. Characterization of the individual suspension particles in the Ems Estuary. (See complete entry in Section VIII.)

†**Besnier, G.** 1983. Equipment of the estuary of the Vilaine; Building of Arzal Dam (L'amenagement de l'estuaire de la Vilaine; Construction du Barrage d'Arzal). (See complete entry in Section V.)

Bhogal, V. K. 1989. A sediments dynamics model for flood tidal delta evolution. (See complete entry in Section VI.)

Biggs, R. R., and Howell, B. A. 1984. The estuary as a sediment trap: Alternate approaches to estimating its filtering efficiency. In *The estuary as a filter,* ed. V. S. Kennedy, 107-129. Orlando: Academic Press.

The trapping efficiency of estuaries for particulate matter is reviewed using box models, evaluation of historical changes in bathymetry, geochronologic data, and the capacity-inflow ratio. Most of the open water estuaries of the world are more or less efficient sediment "filters." Those which are not have evolved to estuarine deltaic environments. For estuarine systems that we have evaluated, it appears that biologically mediated sedimentation processes have the capability to overwhelm all others in the deposition of fine sediments. For example, the major filter-feeding species in Delaware Bay are capable of depositing 200 times the annual fluvial input of suspended sediment. (61 refs)

Biswas, A. N., and Bandyopadhyay, K. K. 1987. Scour at Haldia oil jetty on the Hugli Estuary. *Bulletin of the Permanent International Association of Navigation Congresses* 58:57-68.

The estuary of the Hugli in the State of West Bengal, India, accommodates a subsidiary deep dock system at Haldia on the right bank, specially designed for traffic in petroleum, coal, fertilizer, and iron ore. A riverside oil jetty (a component of this dock complex) was commissioned in 1968 to berth tankers of draughts within 10.70 m and 12.20 m at about 1,000 m upstream of the local entrance within a zone

of prevailing depths of the order of 9 m below chart datum (BCD). The jetty is designed for a throughput of 3 million tons of crude per annum to the refinery located there and is the only river oil terminal in the eastern region of India. To permit loaded tankers to remain berthed safely even at low water, five 300-m-long semipermeable groynes with crest at 0.4 m above chart datum (ACD) were constructed between 1968 and 1970 on the opposite bank to induce increase in depth at the jetty. Their spacings were finalized after hydraulic model investigations. The depths progressively increased to 14 m BCD by 1975 and 20 m BCD by 1978. The recent depths exposed the two front rows of vertical and raker piles of the jetty driven between 21 m and 23 m BCD. The threat of collapse was averted through intensive efforts of armoring the bed. This paper discusses the geo-hydro morphometry of the estuary, effect of training works, influence of berthing of tankers on this bed, and other relevant features. (3 refs)

Blaauw, H. G., Lindenberg, J., Strating, J., and Vellinga, P. 1983. Numerical models in port design. (See complete entry in Section VI.)

Bodge, K. R., and Dean, R. G. 1987. Short-term impoundment of longshore sediment transport. Miscellaneous Paper CERC-87-7. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

The cross-shore distribution of longshore sediment transport is investigated through the distribution of sediment impounded against a shore-perpendicular barrier over short-term intervals in field and laboratory environments. For each field experiment, a low-profile groyne was deployed across a natural beach in less than 8 hr, and profiles near the groyne were repeatedly surveyed for 8 to 20 hr thereafter. For each laboratory experiment, a low-profile barrier was installed across a pre-equilibrated fine sand model beach, and profile changes near the barrier were measured after 5 to 40 min of regular, obliquely incident, unidirectional wave action. Breaking wave angle and longshore current and wave height across the surf zone were also measured. The effects of cross-shore transport and tidal fluctuation were addressed in the survey data, and the effectiveness of the barriers as impoundment agents is discussed. Local downdrift profile changes were found to be poor indicators of the local updrift impoundment. In general, the longshore transport profiles were found to be bimodal with peaks just landward of the breakpoint and near the shoreline. The relative significance of the longshore transport shifted from the near-breakpoint peak to the near-shoreline peak as the wave condition varied from spilling to collapsing breakers. Alternately stated, the longshore transport distribution appeared strongly beach profile dependent, as transport was most pronounced over local regions of high bed steepness. Between 10 and 30 percent of the total longshore transport was observed seaward of the breakpoint for all cases. Longshore transport in the swash zone represented at least 5 to 60 percent of the total transport where the largest swash contributions were associated with plunging/collapsing and collapsing surf conditions. A simple model is proposed to describe the normalized longshore transport distribution across the swash and surf zone as a function of the local longshore current, beach slope, and dissipation of wave energy per unit surf volume. The setup, longshore current, and longshore transport are described for an equilibrium beach profile which is finite-sloped at the shoreline. The shoreward convection of longshore current by wave mass transport is also discussed in relation to the longshore transport distribution. (99 refs).

Boersma, J. R., and Terwindt, J. H. J. 1981. Neapspring tide sequences of intertidal shoal deposits in a mesotidal estuary. (See complete entry in Section I.)

Boesch, D. F., Day, J. W., Jr., and Turner, R. E. 1984. Deterioration of coastal environments in the Mississippi Deltaic Plain: Options for management. (See complete entry in Section V.)

Boggs, S., Jr., and Jones, C. A. 1976. Seasonal reversal of flood-tide dominant sediment transport in a small Oregon estuary. *Geological Society of America Bulletin* 87(3):419-426.

The Sixes River in southwestern Oregon has a summer discharge of only about 2 cu m/sec. During these low-discharge conditions, a flood-dominated system of bottom tidal currents develops in the estuary and a deltalike sill, as much as 1.5 m in height, builds across the mouth of the estuary by upstream progradation. Flood-tide currents move across this sill at velocities of as much as 90 cm/sec 15 cm above the bottom, but the velocity of ebb-tide currents usually does not exceed about 40 cm/sec. Dispersal patterns of dyed sediment injected at the river mouth during low river discharge showed that flood-tide currents transport sand across the sill and up the estuary as far as 0.8 km (about one-fourth the length of the estuary) in a single flood-tide phase. During ebb tide, the sill impedes movement of salt water along the estuary bottom, producing a sharply stratified two-layer water system. River discharge

after winter storms may increase to more than 400 cu m/sec, and large quantities of detritus, including gravel, are transported downstream into and through the estuary. High river discharge also causes erosion of the sill, greatly reducing the sediment-trapping capacity of the estuary. The finer fluvial detritus, together with fine marine sediment deposited during the summer, is swept from the estuary, leaving it floored largely by gravel. (24 refs)

†**Bollinger, M. S.** 1986. Radium isotopes in salt marsh and estuarine environments. (See complete entry in Section VIII.)

Borah, D. K., and Balloffet, A. 1986. Sediment routing model for estuarine harbors. (See complete entry in Section VI.)

Bose, S. K., Ray, P., and Dutta, B. K. 1987. Mathematical models for mixing and dispersion in forecasting and management of estuarine water quality. (See complete entry in Section I.)

†**Boynton, J. E.** 1985. The influence of current velocity on nutrient and oxygen exchanges between estuarine sediments and the water column. Ph.D. diss., University of Maryland, College Park.

The influence of current velocities on the exchange of dissolved oxygen, ammonium, phosphate and silicate across the sediment/water interface was investigated. In situ benthic chambers were used to investigate the influence of current velocity on nutrient flux, sediment nutrient pool depletion, silt/clay sediment resuspension and benthic ciliate community response. A laboratory microcosm system was used to investigate short- and long-term nutrient flux characteristics and to determine the influence of ciliates on the net flux of ammonium. Oxygen flux increased with increasing current velocity while nutrient fluxes were more variable, increasing with current velocity in many cases, but also decreasing or showing erratic short-term patterns. The complexity of fluxes was due, in part, to the effects of resuspension and possibly to uptake by benthic diatom communities. Current velocity affected the depth of the benthic ciliate community in sands. Redox profiles of the sediments altered in response to flow and in a manner which paralleled ciliate community movements. Ciliates were found to augment significantly the flux of oxygen and ammonium between sandy sediments and overlying water.

Brogdon, N. J., Jr., and White, D. M. 1985. Newburyport Harbor, Massachusetts; Report 2, Design for hydrodynamics, salinity, and sedimentation; Hydraulic model investigation. (See complete entry in Section VI.)

Burton, J. H., and Healy, T. R. 1985. Tidal hydraulics and stability of the Maketu Inlet, Bay of Plenty. In *1985 Australasian conference on coastal and ocean engineering,* 2-6 December 1985, Christchurch, New Zealand, 2:139-150. Barton, A.C.T., Australia: The Institution of Engineers, Australia.

The results of an investigation of sedimentation and hydraulic regime changes of the Maketu tidal inlet are reported. Maketu has been transformed into an estuarine lagoon since the artificial diversion of the Kaituna River in 1956. Reduction of the flushing ability of the estuarine ebb tidal flow after 1956 was coincident with development of an accreted flood tidal delta and extensive buildup of sandy intertidal flats. Aerial photograph analysis, tidal prism calculations, and bathymetric surveys all confirm that the estuary is infilling with littoral sediment. Detailed bathymetric survey data indicate an average infilling rate of ~ 1500 m^3/year over the lower estuary, realizing a vertical accretion rate of ~ 0.7 cm/year. This rate may be increased episodically by the contribution of spit-derived sediment, as occurred in 1978 following a storm-induced spit breach, that led to massive shoaling inside the entrance. (13 refs)

Butler, H. L. 1986. Advanced numerical models for coastal currents and sediment transport. (See complete entry in Section VI.)

Caillat, J.-M. 1983. Effect of salinity on deposit distribution in estuarian channels. (See complete entry in Section III.)

Cannon, G. A., Bretschneider, D. E., and Holbrook, J. R. 1984. Transport variability in a fjord. In *The estuary as a filter,* ed. V. S. Kennedy, 67-78. Orlando: Academic Press.

Bottom water renewal in Puget Sound has been found to occur over short intervals several times during the year and is dependent on tidal and mixing processes over the entrance sill. In addition, the inflow of new bottom water entrains some fraction of seaward-flowing upper water at the landward side of the sill. This process acts as a "filter" in that some dissolved and suspended contaminants do not leave the system,

but rather make one or more circuits through the basin and possibly contribute to some unknown amount of long-term accumulations. (5 refs)

Carson, B., Ashley, G. M., Lennon, G. P., Weisman, R. N., Nadeau, J. E., Hall, M. J., Faas, R. W., Zeff, M. L., Grizzle, R. E., Schuepfer, F. E., Young, C. L., Meglis, A. J., Carney, K. F., and Gabriel, R. 1988. Hydrodynamics and sedimentation in a back-barrier lagoon-salt marsh system, Great Sound, New Jersey -- A summary. *Marine Geology* 82(1/2):123-132.

Southern New Jersey is a barrier island coast, characterized by a tide-dominated hydrographic regime. Great Sound, a shallow, open lagoon which is fed by tidal channels within the back-barrier salt marsh complex, is a sediment sink, apparently for detritus imported from the inner continental shelf through two tidal inlets. Study of the system tidal hydrodynamics and sediment accumulation patterns provides the basis for a numerical sedimentation model. This model predicts rapid accumulation of coarse-grained sediment near the Intracoastal Waterway which cuts through Great Sound, and dominance of storm-related sedimentation events. Observations generally confirm the model predictions. Sands are deposited rapidly on flood tidal deltas associated with the two major channels, Great Channel and Ingram Thorofare, and along the Intracoastal Waterway. Finer detritus is transported predominantly as organic-mineral aggregates, and accumulates slowly in the southwestern and eastern parts of the sound. Resuspension of bottom sediments is common in the shallow sound due to wave action and flood tidal currents on the deltas. Low tidal flow velocities over much of Great Sound and the presence of macroalgae in some locations, however, promote net accumulation. Although sediment deposition and accumulation data are variable, the range of accumulation rates suggests that recent accretion in Great Sound is approximately equivalent to the local sea-level rise of 4 mm/year. (24 refs)

Carson, B., Carney, K. F., and Meglis, A. J. 1988. Sediment aggregation in a salt-marsh complex, Great Sound, New Jersey. *Marine Geology* 82(1/2):83-96.

Suspended sediments in a major tidal channel in southern New Jersey consist dominantly of three inorganic particle types: single grains, organic-mineral aggregates, and fecal pellets. Single mineral grains range from clays (<2 μm) to fine sands (200 μm), but are dominant only in size fractions above 88 μm. Organic-mineral aggregates are characterized by low settling velocities ($<4.7 \times 10^{-2}$ cm/sec) and densities (<1.4 mg/m^3), and comprise approximately 70 percent of the suspensate under fair-weather conditions. Fecal pellets are somewhat more dense (1.7 to 1.8 mg/m^3) and settle more rapidly (4.7×10^{-2} to 5×10^{-1} cm/sec) than organic-mineral aggregates. Because of the contrasting settling velocities, organic-mineral aggregates constitute an ever-present background suspensate population, whereas single grains and fecal pellets are dominant only on maximum tidal flow or under storm conditions. Organic-mineral aggregates are composed almost exclusively of grains smaller than 6 μm, so that they are the dominant vehicle by which fine-grained particles are transported and deposited. Fecal pellets are most commonly comprised of a wide range of particle sizes, although occasionally their constituent grains exhibit a well-defined mode of particles $\approx 6 < 16$ μm in size. Given their relatively rapid settling velocities, fecal pellets are probably an important mechanism by which salt- and clay-size particles are introduced to the coarse-grained deposits (sands) which characterize the major tidal channels. (43 refs)

Casapieri, P. 1984. Environmental impact of pollution controls on the Thames Estuary, United Kingdom. (See complete entry in Section IV.)

Castillo, F. P. 1983. Historical coastline changes at the southern shore of the Gulf of Venezuela. (See complete entry in Section V.)

Chaloin, B., Péchon, P., and Coëffé, Y. 1985. Hydraulic studies of the bed evolution of the River Canche Estuary and of the Dunkirk Harbour extensions. (See complete entry in Section VI.)

†**Chaoyu, W.** 1986. A dynamics and sedimentology study of eastern Atchafalaya Bay, Louisiana. Ph.D. diss., Louisiana State University and Agricultural and Mechanical College, Baton Rouge.

A new Mississippi River Delta is building in Atchafalaya Bay of south-central Louisiana as a result of a upstream natural diversion in river course. The present study focuses on several distinct but complementary aspects of the physical processes of the modern Atchafalaya River Delta. Coherence analysis reveals that the subtidal fluctuations of water stage and current velocity in the estuarine area are closely related to atmospheric forcing at different time scales. The water stage fluctuations at Morgan

City had significant variance at time scale 2.5-10 days which was driven by local longitudinal (north-south) winds. There were also fluctuations at periods of 3 days which were the result of up-bay propagation of sea level fluctuations generated by longshore (west-east) winds. In winter local longitudinal winds were dominant, and in summer coastal Ekman flux driven by longshore winds became more pronounced. It is possible to estimate by a linear model the subtidal current driven by winds if enough long-term records are available. Several characteristics (e.g., annual sediment flux, seasonal variation in suspended sediment, grain size variation, abnormally large floods and sediment transport, delta growth rate, and channel geometry, etc.) of sediment input from the Atchafalaya River, important for understanding deltaic depositional processes are examined. Cluster analysis, based on grain size distribution, is applied to three sets of sediment samples totaling 563 to determine the natural grouping of the sediments in Atchafalaya Bay. Clusters produced proved to be sedimentologically meaningful and environmentally significant. Each cluster is related to certain environment(s) of deposition identified by previous studies. Based on the classification established, sediment samples from unknown environments in the study area can be objectively identified based on their grain-size distribution. Based on nonparametric statistical tests, seasonal variation in sediment grain size differs among delta lobes. This can be explained by seasonal variations of atmospheric forcings and the difference in elevation and location of delta lobes.

†**Chen, C.-L.** 1985. Simulation of hydrodynamics and water quality in a well-mixed estuary by using finite element methods. (See complete entry in Section VI.)

†**Chrzastowski, M. J.** 1986. Stratigraphy and geologic history of a Holocene lagoon: Rehoboth Bay and Indian River Bay, Delaware. Ph.D. diss., University of Delaware, Newark.

Holocene lithostratigraphy and geologic history of Rehoboth Bay and Indian River Bay lagoons were examined based on 96 vibracores from the bays and tributary tidal streams and 181 core records from previous investigations. The sublagoonal pretransgression surface consists of antecedent stream valleys and paleointerfluves. Maximum valley depth is -27 to -29 m mean sea level (MSL) where two principal valleys (Love/Herring Creek and Indian River) cross beneath the bay mouth barrier. Beneath 50 percent of the lagoon-barrier system the pretransgression surface depth is -5 m MSL or less. An estimate of total volume of Holocene deposition landward from the bay mouth barrier equals 0.67 km^3 ($\pm$32 percent) which is divisible into four principal lithosomes: tidal stream mud (43 percent); marsh mud (25 percent); flood-tidal delta/barrier sand (18 percent); and lagoonal mud (9 percent). The lagoonal and barrier sediments are areally extensive but a relatively thin cover to the main body of the transgressive sequence which is sediment deposited in tidal streams and fringing salt marsh. In general, lithosome three-dimensional form is tabular with a symmetry axial to the sublagoonal antecedent valleys. In the inner shelf area off coastal Delaware, the ancestral Love/Herring Creek and Indian River were initially tributary to an ancestral Delaware River (13,000 - 11,000 B.P.), then tributary to an ancestral Delaware Bay (11,000 - 7,000 B.P.), and subsequent to 7,000 B.P. marginal to an open-ocean coast. First-approximation fine-grained sediment budgets indicate that throughout the transgression history the depositional system has been inverse-infilled with fine-grained sediment supply likely primarily derived from the Delaware Estuary. Sediment supply may have been sufficient for marsh mud accretion to keep pace with sea level rise while the depositional system was marginal to an estuarine coast. However, once marginal to an open-ocean coast, the estuarine fine-grained sediment supply diminished. With continued sea level rise and transgression extending across paleointerfluves, rate of sea level rise exceeded rate of marsh mud accretion, and progressing laterally from ancestral tidal streams a lagoonal open-water area developed.

Chu, Y.-H., and Chen, H. S. 1985. Bechevin Bay, Alaska, inlet stability study. (See complete entry in Section VI.)

†**Cifuentes, L. A.** 1987. Sources and biogeochemistry of organic matter in the Delaware Estuary. (See complete entry in Section VI.)

Cochran, J. K. 1984. The fates of uranium and thorium decay series nuclides in the estuarine environment. In *The estuary as a filter,* ed. V. S. Kennedy, 179-220. Orlando: Academic Press.

Naturally occurring radionuclides of the uranium and thorium decay series are useful in studying estuarine geochemical processes ranging from the removal of reactive nuclides from the water column to the mobilization and transport of chemical species in the sediment column. Although uranium isotopes generally show conservative behavior during estuarine mixing, removal from solution can occur at low

salinities or in estuaries high in dissolved organic matter. Uranium in estuarine sediments also displays a digenetic chemistry linked to oxidation-reduction. In contrast to uranium, radium isotopes are released during estuarine mixing. Mechanisms of release include desorption from suspended sediments and the mobilization of radium from bottom sediments. The latter is demonstrated by measurements of ^{226}Ra and ^{228}Ra in sediment pore waters. The thorium isotopes ^{234}Th and ^{228}Th, produced by decay of soluble parents ^{238}U and ^{228}Ra, are good analogs for chemical species which interact strongly with particles in the estuary. Both have been used to estimate removal times of thorium from solution to particles. The distribution of ^{234}Th and ^{228}Th in sediments is governed primarily by particle mixing by the benthic fauna, and both isotopes serve as chronometers to determine mixing rates. ^{210}Pb and its daughter, ^{210}Po, also serve as tracers of reactive nuclides in the estuarine environment. Both are removed rapidly to bottom sediments. Although ^{210}Pb is a longer lived tracer than ^{234}Th or ^{228}Th, its depth distribution in estuarine sediments is also affected by bioturbation. Successful reconstruction of sediment chronology in the estuary thus requires the application of several tracers with different half-lives and independent information on the sediment budget of the area. (66 refs)

Coenen, R. C. A. 1986. Water quality management for the Dutch sector of the North Sea. (See complete entry in Section I.)

Cole, P., and Miles, G. V. 1983. Two-dimensional model of mud transport. (See complete entry in Section VI.)

Collins, M. B., and Ferentinos, G. 1984. Residual circulation in the Bristol Channel, as suggested by Woodhead sea-bed drifter recovery patterns. (See complete entry in Section I.)

Colman, S. M., Berquist, C. R., Jr., and Hobbs, C. H. III. 1988. Structure, age and origin of the bay-mouth shoal deposits, Chesapeake Bay, Virginia. *Marine Geology* 83(1/4):95-113.

The mouth of Chesapeake Bay contains a distinctive shoal complex and related deposits that result from the complex interaction of three different processes: (a) progradation of a barrier spit at the southern end of the Delmarva Peninsula, (b) strong, reversing tidal currents that transport and rework sediment brought to the bay mouth from the north, and (c) landward (bayward) net nontidal circulation and sediment transport. Together, these processes play a major role in changing the configuration of the estuary and filling it with sediment. The deposits at the mouth of the bay hold keys both to the evolution of the bay during the Holocene transgression and to the history of previous generations of the bay. The deposit associated with the shoals at the mouth of the bay, the bay-mouth sand, is a distinct stratigraphic unit composed mostly of uniform, gray, fine sand. The position and internal structure of the unit show that it is related to near-present sea level, and thus is less than a few thousand years old. The processes affecting the upper surface of the deposit and the patterns of erosion and deposition at this surface are complex, but the geometry and structure of the deposit indicate that it is a coherent unit that is prograding bayward and tending to fill the estuary. The source of the bay-mouth sand is primarily outside the bay in the nearshore zone of the Delmarva Peninsula and on the inner continental shelf. The internal structure of the deposit, its surface morphology, its heavy-mineral composition, bottom-current studies, comparative bathymetry, and sediment budgets all suggest that sand is brought to the bay mouth by southerly longshore drift along the Delmarva Peninsula and then swept into the bay. In addition to building the southward- and bayward-prograding bay-mouth sand, these processes result in sand deposition tens of kilometers into the bay. (38 refs)

Copeland, R. R. 1986. San Lorenzo River sedimentation study; Numerical model investigation. (See complete entry in Section VI.)

Corapcioglu, M. Y. 1987. Pressure change and surface expansion in salt marshes due to tidal inundation. *Water Resources Research* 23(10):1996-2000.

Infiltration of water across the surface-water interface of a marsh in areas flooded due to the tides has been known to cause swelling of sediments. The sudden tidal inundation in an unflooded soil creates a head gradient at the surface of the unsaturated soil above the water table. When water infiltrates into the soil under this gradient, the suction head in the unsaturated domain decreases, and the pore pressure in the saturated zone increases with time, resulting in swelling of highly compressible marsh soils. A one-dimensional mathematical model which consists of a mass conservation equation, quasi-static equilibrium equations, stress strain relations for an assumed perfectly elastic solid matrix, and a variable total stress expression has been employed to obtain a numerical solution for pore pressure change and swelling due to tidal inundation. Numerical results are presented

graphically at the spatial and temporal points of interest for a constant depth of ponding of water at the marsh surface resulting from tidal inundation. Results show that swelling of soil is primarily governed by the initial head gradient across the marsh surface-water interface. (23 refs)

Crickmore, M. J. 1982. Data collection -- Tides, tidal currents and suspended sediment. (See complete entry in Section VII.)

Cuff, W. R., and Tomczak, M., Jr., ed. 1983. *Synthesis and modelling of intermittent estuaries; A case study from planning to evaluation.* (See complete entry in Section VI.)

Curtis, R. J. 1985. Tidal recirculation of dredge spoil: Major sedimentary process in Lyttelton Harbour, South Island, New Zealand. In *1985 Australasian Conference on Coastal and Ocean Engineering,* 2-6 December 1985, Christchurch, New Zealand, 1:329-338. Barton, A.C.T., Australia: The Institution of Engineers, Australia.

Circulation and bed sediment patterns in Lyttelton Harbor were examined to determine the primary cause of channel siltation. Estimates of sediment input from erosion of the catchment and the harbor bed were made, and long-term spatial sedimentation patterns were established. Rates of spoil loss from dredge dumping sites were determined and the transport and deposition of spoil were predicted from circulation and near-bed sediment patterns. It was established that spoil recirculation by rotatory tidal currents is the single main cause of channel siltation. Dredging operations represent the major sedimentary process in the harbor, resulting in the redistribution of up to 1,000,000 tones of sediment annually. (5 refs)

Dai, Z., and Zhou, C. 1986. The fluvial process and regulation of macrotidal estuaries in China. (See complete entry in Section VIII.)

Dame, R. F. 1982. The flux of floating macrodetritus in the North Inlet estuarine ecosystem. *Estuarine, Coastal and Shelf Science* 15(3):337-344.

An estimate of floating macrodetritus flux in a salt marsh-dominated estuarine ecosystem indicates that this material is exported regularly. However, the amount of macrodetrital material exported is small, less than 1 percent of the net marsh primary productivity. The export of floating macrodetritus is seasonal with maximum values in summer. (12 refs)

Dankers, N., Binsbergen, M., Zegers, K., Laane, R., and van der Loeff, M. R. 1984. Transportation of water, particulate and dissolved organic and inorganic matter between a salt marsh and the Ems-Dollard Estuary, The Netherlands. *Estuarine, Coastal and Shelf Science* 19(2):143-165.

Transport processes were studied in a gully between a salt marsh and an estuary. After storm tides, ebb currents in the gully reached high values. It is concluded that particulate matter (both organic and inorganic) is imported into the marsh. Coarse organic debris is exported during storm tides, but this amount is low when compared with the primary production on the marsh. Exports are shown for dissolved organic carbon, ammonia, phosphate, and silica, while nitrate and possibly nitrite are imported. Organic matter derived from in situ production and net import is buried and partly mineralized in the marsh. (64 refs)

Dayananda, H. V., and Gerritsen, F. 1983. Sedimentation studies carried out on a small harbour sited in an area of high littoral drift. In *International conference on coastal and port engineering in developing countries,* 20-26 March 1983, Colombo, Sri Lanka, II:1109-1125. Colombo, Sri Lanka: Conventions (Colombo) Ltd.

This paper describes investigations at a fishing harbor, Beruwala, Sri Lanka, on the siltation observed after harbor extension. It discusses analysis of wave data and tidal and current flow, and describes measurements to determine the pattern of the longshore drift effects. Sediment concentration sampling and depth soundings were used.

de Boer, P. L., van Gelder, A., and Nio, S. D., eds. 1988. *Tide-influenced sedimentary environments and facies.* Dordrecht, Holland: D. Reidel Publishing (sold and distributed in the USA and Canada by Kluwer Academic Publishers, Norwell, MA.).

This book contains papers expanded from presentations given at the Symposium on Clastic Tidal Depositions held at Utrecht in 1985 and some additional papers. The tidal deposits discussed include both modern deposits and examples from the stratigraphic column, and they range from shelf environments to mud flats. The book is divided into three sections: Offshore Tidal Deposits, Near- and Inshore Tidal Deposits, and Biological Aspects of Tidal Deposits.

Contents: An episodic view of shallow marine clastic sedimentation, by R. H. Dott, Jr. (16 refs); Preservation of marine sand wave structures, by A. H. Stride (31 refs); Tidal sand ridges on the East China Sea Shelf, by Yang Chang-shu and Sun Jia-song (13 refs); Bypassing of sand over sand waves and through a sand wave field in the central region of the southern north sea, by D. B. Smith (9 refs); Morphological development of the Sandettie-South Falls Gap: A degeneration ebb dominated tidal passage in the southern north sea, by D. B. Smith (16 refs); Stability of an offset kink in the North Hinder Bank, by D. B. Smith (14 refs); Direct observation of longitudinal furrows in gravel and their transition with sand ribbons of strongly tidal seas, by R. H. Belderson, J. B. Wilson, and N. A. Holme (9 refs); Relation between superficial sediment grain-size and morphological features of the coastal ridges off the Belgian coast, by Ph. De Maeyer and S. Wartel (17 refs); The morphology of the Dutch shoreface between Hook of Holland and Den Helder (The Netherlands), by J. Wiersma and J. S. L. J. van Alphen (25 refs); Reworking of former ebb-tidal deltas into large longshore bars following the artificial closure of the tidal inlets in the southwest of the Netherlands, by L. H. M. Kohsiek (18 refs); Geometry, structure and geodynamics of a sand wave complex in the southeast margin of the Eocene Catalan Basin, Spain, by C. Santisteban and C. Taberner (38 refs); The Vlierzele sands (Eocene, Belgium): A tidal ridge system, by R. Houthuys and F. Gullentops (24 refs); Tidal transverse bars building up a longitudinal sand body (middle Eocene, Belgium), by R. Houthuys and F. Gullentops (26 refs); Pseudo-Tidal Sedimentation in a Non-Tidal Shelf Environment (Southeast African Continental Margin), by B. W. Flemming (73 refs); The Corrubedo Tidal Inlet, Galicia, N.W. Spain: Sedimentary processes and facies, by F. Vilas, A. Sopena, L. Rey, A. Ramos, M. A. Nombela, and A. Arche (20 refs); Sedimentary processes on a sandy shoal in a mesotidal estuary (Oosterschelde, The Netherlands), by L. H. M. Kohsiek, H. J. Buist, P. Bloks, R. Misdorp, J. H. van der Berg, and J. Visser (18 refs); Paleotidal levels in tidal sediments (3800 - 3635 BP); compaction, sea level rise and human occupation (3275 - 2620 BP) at Bovenkarspel, NW Netherlands, by Th. B. Roep and J. F. Van Regteren Altena (34 refs); Palaeo-tidal reconstruction of inshore tidal depositional environments, by J. H. J. Terwindt (87 refs); Mudflat deposition along the Wenzhou coastal plain in southern Zhejiang, China, by Wang Bao-can and D. Eisma (8 refs); Process and pattern of sediment mixing in a microtidal coastal lagoon along the west coast of South Africa, by B. W. Flenning (36 refs); The triangular diagram used for classification of estuarine sediments: A new approach, by M. Pejrup (25 refs) Characteristic features of modern tidal flats in cold regions, by J. C. Dionne (61 refs); Example of tidal current periodicities from an Upper Cretaceous sandstone succession (Anambra Basin, S. W. Nigeria), by K. O. Ladipo (15 refs); Inner shelf-shoreface-intertidal transition, Upper Precambrian, Port Askaig Tillite, Isle of Islay, Argyll, Scotland, by L. G. Kessler and I. G. Gollop (34 refs); Transition from alluvial plain to tide-dominated coastal deposits associated with the Tournaisian marine transgression in SW Ireland, by J. A. Diemer and J. S. Bridge (96 refs); Tide- and wave-influenced depositional environments in the Psammites du Condroz (U Famennian) in Belgium, by J. Thorez, E. Goemaere, and R. Dreesen (22 refs); Modern point bar deposits analogous to the Athabasca oil sands, Alberta, Canada, by D. G. Smith (31 items); Estuarine tidal channel and nearshore sedimentation of a Late Cretaceous epicontinental sea, Drumheller, Alberta, Canada, by R. A. Rahmani (80 refs); Sediment-organism zonation and the evolution of Holocene tidal sequences in southern Australia, by A. P. Belperio, V. A. Gostin, J. H. Cann, and C. V. Murray-Wallace (41 refs); Intertidal bedforms, sediment transport, and stabilization by benthic micro-algae, by J. Grant (44 refs); Sediment stabilization by benthic diatoms in intertidal sandy shoals; qualitative and quantitative observations, by P. C. Vos, P. L. de Boer, and R. Misdorp (22 refs).

D'Elia, C. F. 1987. Nutrient enrichment of the Chesapeake Bay: Too much of a good thing. (See complete entry in Section IV.)

Delft Hydraulics Laboratory. 1986. Special issue on estuaries and coastal seas. (See complete entry in Section VI.)

Delo, E. A., and Ockenden, M. C. 1989. Prediction of siltation at a point. (See complete entry in Section VI.)

de Mowbray, T., and Visser, M. J. 1984. Reactivation surfaces in subtidal channel deposits, Oosterschelde, Southwest Netherlands. (See complete entry in Section I.)

De Resseguier, A. 1983. A portable coring device for use in the intertidal environment. (See complete entry in Section VII.)

Dietrich, J., Hagstron, A., and Navntoft, E. 1983.

Studies of the effect of a barrage on sedimentation. In *International conference on coastal and port engineering in developing countries,* 20-26 March 1983, Colombo, Sri Lanka, II:1218-1232. Colombo, Sri Lanka: Conventions (Colombo) Ltd.

This paper describes modelling of the effects of a future barrage on the sedimentation conditions in the estuary of the Gambia River. The sediment transport model is based upon a hydrodynamic model S21-11 for the estuary and part of the upstream river system. S21 refers to a two-dimensional estuary flow model which is coupled with S11, a one-dimensional river-flow model. It also presents formulae for suspended load and bed-load transport and discusses application of the system. It presents results of verification from field data and discusses results which indicate an outgoing net transport of the fine sediments in suspension increased by the presence of a barrage. Bed-load transport results are also examined. (4 refs)

Doerffer, R. 1985. Observations of the suspended matter distribution dynamics in the Elbe Estuary from time series aerial photographs. (See complete entry in Section VIII.)

Donnell, B. P., and McAnally, W. H., Jr. 1985. Spectral analysis of Columbia River Estuary currents. (See complete entry in Section I.)

Douglass, S. L. 1987. Coastal response to jetties at Murrells Inlet, South Carolina. (See complete entry in Section V.)

Douglass, S. L. 1987. Coastal response to navigation structures at Murrells Inlet, South Carolina: Main text and appendixes A and B. (See complete entry in Section VIII.)

Douvillé, J.-L., and Riaux, C. 1986. On the dynamics of a tidal estuary: Estimation of the principal factors (Estimation des paramètres foundamentaux de la dynamique d'un estuaire à marées). (See complete entry in Section VI.)

Druery, B. M., and Geary, M. G. 1985. The measurement of sediment transport in N.S.W. estuaries. In *1985 Australasian conference on coastal and ocean engineering,* 2-6 December 1985, Christchurch, New Zealand, 2:151-160. Barton, A.C.T., Australia: The Institution of Engineers, Australia.

The paper discusses methods used by the Public Works Department to assess the tidal transport of medium grained sand in the estuaries of New South Wales. Methods vary from qualitative to quantitative and comprise sedimentology, coring and radiometric dating, delta front progradation, photogrammetry, bed forms, and radioisotope tracing. These methods are discussed within the context of a major study of sedimentary processes in Port Hacking. The relative merits of each are examined from the viewpoint of cost, limitations, and effectiveness. (13 refs)

†**Duursma, E. K.** 1983. Aspects of resident time in estuaries. (See compete entry in Section IV.)

Dyer, K. R. 1986. *Coastal and estuarine sediment dynamics.* New York: John Wiley & Sons.

The book has chapters on (2) sediment, (3) fluid flow, (4) sediment movement (noncohesive!), (5) sediment movement under waves, (6) sediment suspension, (7) sediment transport rate, (8) cohesive sediments, (9) estuarine sedimentation, (10) coastal sedimentation, and (11) beach processes and gives a comprehensive survey of present knowledge by referring to a large number of recent research publications. Also included are useful background sections describing the physical processes influencing the sediments, e.g., on waves and on tides (chapter 4), on types of estuaries (chapter 9), and on shallow-water wave processes (chapter 11). (539 refs)

†**Eisma, D., Gaast, S. J. van der, Martin, J. M., and Thomas, A. J.** 1978. Suspended matter and bottom deposits of the Orinoco Delta: Turbidity, mineralogy and elementary composition. *Netherlands Journal of Sea Research* 12(2):224-251.

A three-layer stratification was found in the Boca Grande Estuary: a layer of fluid mud near the bottom, a layer of low salinity and low turbidity at the surface, and a salt wedge of high salinity and low turbidity in between. The position of the fluid mud layer is related to the nodal point where the movement of the bottom water changes from a resultant landward to a resultant seaward direction. It is not clear to what extent the formation of the fluid mud is influenced by the dredging of the navigation channel and to spoiling practices. (51 refs)

Elbaz-Poulichet, F., Holliger, P., Huang, W. W., and Martin, J.-M. 1984. Lead cycling in estuaries, illustrated by the Gironde Estuary, France. (See complete entry in Section IV.)

Everts, C. H., and Hartman, G. 1986. Effect of jetty construction on the ocean entrance of the

Columbia River. (See complete entry in Section V.)

Eysink, W. D., and Vermaas, H. 1983. Computational methods to estimate the sedimentation in dredged channels and harbour basins in estuarine environments. (See complete entry in Section V.)

Faas, R. W., and Carson, B. 1988. Short-term deposition and long-term accumulation of lagoonal sediment, Great Sound, New Jersey. *Marine Geology* 82(1/2):97-112.

A study of the deposition, distribution, and compaction of recently deposited sediment was performed in Great Sound--a shallow, low-mesotidal, coastal lagoon in southern New Jersey. Deposition rates determined from weekly and monthly deployment of sediment traps ranged from 5 to 692 mm/year. By contrast, published ^{210}Pb accumulation rates varied from 1 to 5.4 mm/year. Sediment traps collect settling material potentially available for accumulation. Extensive bioturbation of the uppermost 1 m of sediments creates an "apparently" overconsolidated substrate and suggests low accumulation rates. Infilling of the lagoon is a function of *net* sediment accumulation less *net* sediment compaction. The apparent net accumulation rate is modified by local relative sea level rise (4.00 mm/year). A net accumulation rate of at least 4.12 mm/year is required to maintain the existing steady-state condition, i.e., 0.6 m mean low water depth. Accumulation in excess of 4.12 mm/year would result in shoaling and a disequilibrium of the system. Under the maximum ^{210}Pb dated net accumulation of 5.40 mm/year, the sound will fill completely in 488 years (assuming a constant 4.00 mm/year sea level rise). (32 refs)

Fagerburg, T. L. 1989. Winyah Bay, Georgetown, South Carolina, data collection survey report. (See complete entry in Section VIII.)

Farrow, G. E., Allen, N. H., and Akpan, E. B. 1984. Bioclastic carbonate sedimentation on a high-latitude, tide-dominated shelf: Northeast Orkney Islands, Scotland. *Journal of Sedimentary Petrology* 54(2):373-393.

Shell-sands and gravels cover much of the shallow Orkneys shelf at 59° N, accumulating locally into 30-m-high banks at rates up to 540 g/m^2/year (67 cm/1,000 years). Overall, the Orkney shelf sedimentation rate is approximately 10 cm/1,000 years, compared with 3 cm/1,000 years for the entire Scottish continental shelf. Major sandbanks are located off headlands that produce circulation loops in the tidal flow. Regional sand wave orientations reveal a clockwise transport of sediment around the islands, probably resulting from storm wave reinforcement of the tidal asymmetry combined with the net inflow of Atlantic water into the North Sea. Carbonate production is high from the *Modiolus* epifauna. *Modiolus* shell gravels, commonly containing *Glycymeris*, pass laterally into comminuted shell-sands. Within the euphotic zone (down to 40 m), dead shells are weakened by echinoid biting, algal boring, and limpet grazing. Boring by fungi and clionid sponges and grazing by chitons are common but not depth-restricted. Sediments contain 89-95 percent carbonate on the level bottom offshore, but 94-99 percent in sand waves. Mean values for the main skeletal components are bivalves, 46 percent; barnacles, 18 percent; bryozoans, 11 percent; and serpulids, 7 percent. Calcareous algal gravels occur in sheltered areas less than 20 m deep. Bryozoa typify lower energy offshore environments, while more durable barnacle and serpulid debris is concentrated in sand wave fields. The sediments are dominantly calcitic and have a high preservation potential. (43 refs)

Fields, M. L., Weishar, L. L., and Clausner, J. E. 1988. Analysis of sediment transport in the Brazos River diversion channel entrance region. Miscellaneous Paper CERC-88-7. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

A combined office and field study was conducted to evaluate the feasibility of constructing a navigation channel in the Brazos River diversion channel (BRDC). The evaluation was made through an analysis of existing data and a computation of shoaling rates. The office study consisted of an evaluation of the shoaling history of the area, which was determined through quantification of shoreline migration rates and volumetric changes in the growth of the BRDC delta. Nearshore available longshore sediment transport quantities and rates were determined using Littoral Environment Observation (LEO) data. A two-dimensional (2-D) laterally averaged numerical model was used to predict sediment transport in the BRDC for the proposed channel dimensions. A second 2-D numerical wave refraction/diffraction model was used to predict wave propagation over the Brazos river ebb-tide delta and adjacent regions. Field data utilized to run the numerical models consisted of water surface elevations, current velocities, salinities, suspended sediment concentrations, nearshore sediment samples, and bathymetric survey data. Considerations of the hydraulics in the lower

BRDC suggests sediment transport occurs on a seasonal basis, resulting in periodic flushing and shoaling conditions. Shoaling rate calculations for the proposed channel dimensions of 12 ft deep by 125 ft wide with 6-ft overdredging predict an annual maintenance dredging requirement of 735,000 cu yd, with an estimated project duration of approximately 4 months. (50 refs)

Figueres, G., Martin, J. M., Meybeck, M., and Seyler, P. 1985. A comparative study of mercury contamination in the Tagus Estuary (Portugal) and major French estuaries (Gironde, Loire, Rhone). (See complete entry in Section IV.)

FitzGerald, D. M., and Nummedal, D. 1983. Response characteristics of an ebb-dominated tidal inlet channel. (See complete entry in Section I.)

Franzius, O. 1986. Suspended sediment problems in the brackish transition of the tidal Ems River. *Bulletin of the Permanent International Association of Navigation Congresses* 53:37-62.

The brackish transition zone of the Ems is subject to a considerable permanent formation of suspended sediments and deposits. This phenomenon necessitates costly maintenance dredging in the ports and their approaches. The article describes the causes of the suspended sediment processes, the properties of the sediments, the localization and their distribution, the movements linked to tidal currents, as well as the problems that are implied with the clearing of the deposits. The author, moreover, takes a sympathetic interest in the quality of the river water and the problem of absorption of dangerous substances, from the ecological viewpoint, for solid suspended materials and deposits in the estuary of the Ems and the ports. The drainage canal of the Ems and the extension of the Port of Emden (Port de Dollart) are referred to and discussed from the point of view of a possible modification in the formation of suspended sediments and maintenance dredging--the latter by way of an example as to the manner of resolving such problems by measures relevant to hydraulic engineering. (26 refs)

†Frenel, P., Ottmann, F., and Quere, J. 1982. Microbiological pollution in the River Loire Estuary (Pollution microbiologique dans l'Estuaire de la Loire). *Techniques et Sciences Municipales Eau* 2:97-104 (In French).

The sediments in suspension brought forward by the river Loire are gathered in the estuary, forming "a mud plug." These turbid accumulations play an essential part in the repartition of the bacterial flora. During low water, the mud plug is brought up to Nantes around the refuse points of the urban district. These are a storage and concentrations of the flora which are sometimes rich with pathogenic species. On the opposite, during the floods, part of the mud plug is rejected into the outer estuary, bounded with beaches and conchylicol areas. In such conditions, a sensible increase of germs was noticed, the origin of which is fecal.

Frey, R. W., Howard, J. D., Han, S.-J., and Park, B.-K. 1989. Sediments and sedimentary sequences on a modern macrotidal flat, Inchon, Korea. (See complete entry in Section VIII.)

Friedrichs, C. T., and Aubrey, D. G. 1988. Non-linear tidal distortion in shallow well-mixed estuaries: A synthesis. (See complete entry in Section VIII.)

Fromme, G. A. W. 1985. The dynamics of the Keurbooms-Bitou Estuary. (see complete entry in Section I.)

Furumai, H., Kawasaki, T., Futawatari, T., and Kusuda, T. 1988. Effect of salinity on nutrification in a tidal river. (See complete entry in Section III.)

Futawatari, T., Kusuda, T., Koga, K., Araki, H., Umita, T., and Furumoto, K. 1988. Development of a new simulation method for suspended sediment transport in a tidal river. (See complete entry in Section VI.)

Gade, H. G., Edwards, A., and Svendsen, H., eds. 1983. *Coastal oceanography.* (See complete entry in Section I.)

†Gantt, R. G. 1988. The effect of turbidity on the infrared emissivity and thermal mapping of coastal waters. (See complete entry in Section VII.)

Gelfenbaum, G. 1983. Suspended-sediment response to semidiurnal and fortnightly tidal variations in a mesotidal estuary: Columbia River, U.S.A. *Marine Geology* 52(1/2):39-57.

A turbidity maximum is the dominant feature of the suspended sediment concentration field in the Columbia River Estuary, USA. In this estuary, the turbidity maximum is an unsteady feature which changes on semidiurnal, fortnightly, and seasonal time scales. In response to the semidiurnal tides, the turbidity maximum is advected landward and seaward

and may have an excursion of approximately 20 km. In response to the fortnightly tidal variations, the turbidity maximum degenerates, or decreases in concentration, during neap tides and regenerates, or increases in concentration, during spring tides. Finally, in response to seasonal freshwater discharge variations, suspended sediment concentrations in the turbidity maximum increase and its general location is pushed seaward during high discharge conditions; conversely, concentrations decrease and its general location is farther landward during low discharge conditions. The magnitude of suspended sediment concentration variations for these three time scales is similar. Therefore, any consideration of estuarine dynamics and the suspended sediment concentration field in the Columbia River Estuary should include the semidiurnal and fortnightly time scales as well as the seasonal ones. Because the Columbia is a mesotidal estuary and fortnightly tidal variations are not extremely large, it is expected that these time scales (and associated processes) may be important in many other estuarine systems. (35 refs)

Gerritsen, F. 1985. Tidal hydraulics - Historic perspective and future trends in engineering analysis. (See complete entry in Section I.)

Giese, G. L., Wilder, H. B., and Parker, G. G., Jr. 1985. Hydrology of major estuaries and sounds of North Carolina. (See complete entry in Section IV.)

Glegg, G. A., Titley, J. G., Millward, G. E., Glasson, D. R., and Morris, A. W. 1988. Sorption behaviour of waste-generated trace metals in estuarine waters. *Water Science and Technology* 20(6/7):113-121.

Samples of suspended particles have been collected from the turbidity maximum region of the Tamar Estuary, S. W. England. Specific surface areas and porosities of the particles were determined by a BET nitrogen adsorption technique. The role of surface coatings of organic matter and iron (Fe) and manganese (Mn) oxides was examined. The data show that the specific surface area was highest at the turbidity maximum and was associated with high Fe/Mn ratios. The characterized particles were then used in time-dependent adsorption-desorption experiments, with waters from the metal-rich Carnon River, S.W. England. The rates and extents of the sorption processes were interpreted in terms of a two-stage reaction which was related to the microstructures of the particles. Kinetic analyses of the desorption profiles gave rate constants which are of significance in the prediction of the fate of toxic metal wastes discharged into estuaries. (22 refs)

Goh, H. S., Rajendra, A. S., and Pui, S. K. 1983. Coastal problems encountered at Muara Port area in Brunei. (See complete entry in Section I.)

†Golterman, H. L., Sly, P. G., and Thomas, R. L. 1983. *Study of the relationship between water quality and sediment transport.* Paris: Unesco.

This is a guidebook intended to assist in the design, sampling, analysis, and interpretation of sediment studies in rivers, streams, lakes, ponds, and estuaries, particularly where such studies are being initiated for the first time or where the work is being undertaken by water quality staff inexperienced in sediment studies.

Gould, D. J., Dyer, M. F., and Tester, D. J. 1986. Environmental quality and ecology of the Great Ouse Estuary. (See complete entry in Section IV.)

Grad, P. 1986. Jet pumps keep passage clear of tidal sands. *Engineers Australia* 58(17):46.

This brief article discusses one of the world's largest tidal sand bypass systems which has been operating on Queensland's Gold Coast, where it protects the new entrance to a broad and shallow estuary known as the Broadwater. The key components of the sand bypassing works are 10 Genflo jet pumps suspended abut 30 m apart from a jetty extending about 490 m into the sea.

Granat, M. A., Brogdon, N. J., Cartwright, J. T., and McAnally, W. H., Jr. 1989. Verification of the hydrodynamic and sediment transport hybrid modeling system for Cumberland Sound and Kings Bay navigation channel, Georgia. (See complete entry in Section VI.)

Green, T. 1986. The double-diffusive aspects of sedimentation. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:371-377. University, MS: University of Mississippi.

Sediment in suspension can behave like a dissolved salt, when influencing the motions of the sediment/water mixture. In the case where warm, salty, light water overlies colder, fresher, and heavier water, it is well known that double diffusive "salt fingering"

motions can greatly increase the downward flux of salt (over that due to Fickian diffusion). The same should happen when the vertical salt gradient is replaced by a gradient of suspended sediment. The importance of this effect is investigated, using analogous experimental results obtained over the last 15 years with dissolved substances. The results are used to obtain a new estimate for the residence time of a gravitationally stable layer of turbid water. (15 refs)

Halliwell, A. R. 1986. Engineering model for well-mixed tidal basin. (See complete entry in Section VI.)

Hamm, L. 1986. Analysis of the evolution of beds in the Seine Estuary (Analyse de l'evolution des fonds dans l'estuaire de la Seine). (See complete entry in Section VI.)

Han, Z., and Cheng, H. 1986. Two-dimensional sediment mathematical model of Hangzhou Bay. (See complete entry in Section VI.)

Hao-Lin, L. 1986. Numerical computation for two-dimensional riverbed deformation in estuaries. (See complete entry in Section VI.)

Harris, J. E., Hinwood, J. B., Marsden, M. A. H., and Sternberg, R. W. 1979. Water movements, sediment transport and deposition, Western Port, Victoria. *Marine Geology* 30(1/2):131-161.

Western Port is a tidal embayment, and the characteristics of oscillatory tidal currents; overall net and small-scale circulation patterns; and aspects of the mode, frequency, and mass transport of sediment are presented. The results of the studies reported in this volume are both corroborative and complementary, and their integration has resulted in a much better understanding of the bay than could otherwise have been obtained. Consideration of dynamic process, sedimentation patterns, and morphology has allowed the distinction of four "systems" within the bay: (a) High-energy channel/bank system (western entrance to just beyond the confluence zone), characterized by strong tidal currents, varying degrees of surface wave activity, and a sandy substrate. Middle Bank represents the largest individual sand body in Western Port and is associated with intense sediment movement. Sand transported from Middle Bank through the confluence zone supplies and maintains the sandy deposits and beaches in the lower North Arm and East Arm. Seismic evidence coupled with estimates of mass transport of sand suggest that during the Holocene, 10^3 to 10^4 g cm^{-1} year^{-1} have been transported from Middle Bank to Cowes Bank in order to produce the extensive sedimentary complex in that region. (b) Ebb/flood differentiated segments with contrasting intertidal sediments (lower North Arm, Corinella Segment), characterized by clearly differentiated flood- and ebb-dominate zones, sandy and muddy intertidal sediment deposition. (c) Subtidal, partly enclosed mud-deposition basin (Rhyll Segment), characterized as a shallow, subtidal, depositional basin collecting fine sediments. A central clay-size zone is flanked by coarser sediments. Circulation is weak and sediment transport is minimal. (d) Extensive intertidal flat systems with minor channels (Embayment Head), characterized by a web of minor channels, and luxuriant seagrass meadows except in the regions of the Bunyip and Lang Rivers. Local flood- and ebb-dominant transport paths are defined by sandy deposits of reworked or autochthonous Pleistocene sands. (20 refs)

Harris, P. T., and Collins, M. 1988. Estimation of annual bedload flux in a macrotidal estuary: Bristol Channel, U.K. (See complete entry in Section VIII.)

Harrison, S. J., and Phizacklea, A. P. 1987. Vertical temperature gradients in muddy intertidal sediments in the Fourth Estuary, Scotland. *Limnology and Oceanography* 32(4):954-963.

When exposed at low water, muddy sediments tend to develop less steep vertical subsurface temperature gradients than do sandy beach sediments. Changes in these gradients are rapid during tidal inundation. Measurements of subsurface temperature and atmospheric variables were made from an instrument tower at Skinflats on the extensive intertidal mudflats of the Forth Estuary in Scotland. There was a marked seasonal change in the direction and magnitude of gradients. Gradients developed at low water were related to antecedent net radiant energy influx at the mud surface and latent heat flux into the atmospheric boundary layer. The relationship between the change in gradient during an incoming tide and the time of high water showed a well-defined association. (12 refs)

Hayes, M. O. 1983. Role of geomorphological processes in inlet and port-entrance sedimentation problems: An overview. In *International conference on coastal and port engineering in developing countries,* 20-26 March 1983, Colombo, Sri Lanka, II:1126-1138. Colombo, Sri Lanka: Conventions (Colombo) Ltd.

Ratios of sediment volumes in transport to wave and tidal energy influx produce differences in shoal complexes at tidal inlets and port entrances. Detailed studies by the author and associates at 30 inlets on the North American continent provide a basis for the following generalizations: (a) Ebb-tidal deltas (outer shoals) of inlets have a distinct morphological form which consists of a main ebb channel, a terminal lobe, a variety of swash bars scattered over a lobate-shaped swash platform surface, and flanking marginal flood channels (swash channels) dominated by flood currents. (b) Flood-tidal deltas (inner shoals) of inlets have a characteristic shield shape, with the seaward-facing flank being dominated by flood currents. (c) Inlets migrate and bypass sediment in a variety of fashions. An example from the South Carolina coast, North Edisto Inlet, demonstrates the complex nature of sediment transport in the vicinity of a major tidal inlet. Solutions offered for the erosion problems at North Edisto Inlet emphasize engineering practices that mimic the geomorphological processes, rather than build structures that act in discordance with nature. (23 refs)

†**Hayter, E. J.** 1983. Prediction of cohesive sediment movement in estuarial waters. (See complete entry in Section VI.)

Healy, T., Black, K., and de Lange, W. P. 1985. Numerical model field requirements for detailed simulation of currents and sediment transport in large tidal-inlet harbours. (See complete entry in Section VI.)

Hearn, C. J., and Pearce, A. F. 1985. NOAA satellite and airborne sensing of a small-scale, coastal tidal jet. (See complete entry in Section I.)

Heathershaw, A. D., and Codd, J. M. 1985. Sandwaves, internal waves and sediment mobility at the shelf-edge in the Celtic Sea. *Oceanologica Acta* 8(4):391-402.

Considerations of sediment mobility and unusual wavelength pattern changes in large sand waves lying deep in the Celtic Sea suggest that these features are probably formed as a result of internal wave perturbations on a tidally driven stream of sediment transport. In particular it is shown that while currents due to the surface tides alone are capable of transporting the sediments, it is necessary to invoke an internal wave mechanism to give the observed pattern of wavelength change across the sand wave field. Cartwright's internal lee-wave model is found to give qualitative agreement with the observed decrease in sand wave wavelength with increasing distance from the shelf break. (34 refs)

Heathershaw, A. D., and Langhorne, D. N. 1988. Observations of near-bed velocity profiles and seabed roughness in tidal currents flowing over sandy gravels. (See complete entry in Section I.)

Heltzel, S. B., LaGarde, V. E., and Shingler, J. H. G. 1982. Barnegat Inlet hydrographic survey comparison. (See complete entry in Section VIII.)

Hockin, D. C., and Parker, D. M. 1988. The effects of development of a tidal barrage upon the water and sediment quality of the Mersey Estuary (U.K.) and its biota. (See complete entry in Section IV.)

Holz, K.-P., and Heyer, H. 1986. Control of sediment transport in a tidal river. (See complete entry in Section VI.)

Homsi, A. 1986. Port of Itajai and Itajai-Acu Estuary sedimentation and erosion studies. (See complete entry in Section V.)

Horie, T. 1988. The role of modelling in the control of seawater pollution. (See complete entry in Section VI.)

Hoskin, C. M., Burrell, D. C., and Freitag, G. R. 1978. Suspended sediment dynamics in Blue Fjord, Western Prince William Sound, Alaska. *Estuarine and Coastal Marine Science* 7(1):1-16.

Glacier meltwater and suspended discharge in Blue Fjord occur over a brief 5-month period in summer. Suspended sediment concentrations in the meltwater stream reach 300 mg/l, and this sediment forms a surface turbid plume at the fjord head. Suspended sediment concentrations in the surface plume range from 200 mg/l at the head to a few mg/l 5 km away at the mouth. Turbidity does not seem to be related to density structure of the water column. Suspended sediment sinks through the water column, with most sediment settling at slack low water. Sediment trap measurements showed an April sediment flux of 1.5 mg dry sediment per sq cm/day at the head and 2 mg per sq cm/day at the mouth (mostly detrital inorganic silicates in the mud size range). Bottom sediment in the fjord basin is mostly mud, with an admixture of sand at the fjord head. Grain-size modes decrease from an average of 46 micrometers at the head to 8 micrometers 2 km away; no trend is discernable for sediments in the outermost 4 km of

the fjord basin. Mud accumulates in the fjord at the rate of about 100 mm/meltwater year at the head, 10 mm/year in midfjord, and 4 mm/year in the 190-m basin inside the sill at the fjord mouth. (23 refs)

Houston, J. R., Vemulakonda, S. R., Scheffner, N. W., and Ebersole, B. A. 1986. Coastal and inlet processes (CIP) numerical modeling system. (See complete entry in Section VI.)

Huang, Z., Yuan, X., Chen, S., and Qin, H. 1986. The experimental investigation for the improvement of Modaomen Outlet of the Pearl River Estuary in China. (See complete entry in Section VI.)

Hydraulics Research Station. 1981. Severn tidal power. (See complete entry in Section VI.)

Imperato, D. P., Sexton, W. J., and Hayes, M. O. 1988. Stratigraphy and sediment characteristics of a mesotidal ebb-tidal delta, North Edisto Inlet, South Carolina. *Journal of Sedimentary Petrology* 58(6):950-958.

Ebb-tidal deltas can form extensive strandline sand deposits on barrier island shorelines. This paper describes the diagnostic textures, sedimentary structures, and geometry of an ebb-tidal delta in a mesotidal setting at North Edisto Inlet, South Carolina. Bed forms and surface textures at North Edisto Inlet reflect typical ebb-tidal delta circulation patterns. The main ebb channel is dominated by large ebb-oriented bed forms, and channel sediments become finer grained in the seaward direction. At the inlet throat, the coarsest available sediment forms a lag deposit. Marginal flood channels adjacent to the barrier islands are dominated by flood-oriented bed forms composed of medium-grained sand. Channel-margin linear bars, flanked by bed forms with opposing orientations, develop where flood channels approach the main ebb channel. The extensive swash platform is dominated by wave energy, which effectively sorts swash platform sediments. Ebb-tidal delta stratigraphy is dominated by sequences deposited by shifting tidal channels and by the migration of swash bars on the swash platform. Proximally, the ebb-tidal delta sequence is dominated by relatively thick tidal channel deposits which fine upward and have a sharp, disconformable lower contact. Main ebb-channel deposits up to 20 m thick flank the active channel. These deposits are composed primarily of well-sorted, planar-bedded, fine-grained sand. Flaser-bedded sands directly overlie medium- to coarse-grained, seaward-directed, cross-bedded sands at the base of the sequence. Adjacent to barrier islands, marginal flood channel deposits dominate the ebb-tidal delta sequence. These are composed of moderately to intensely burrowed, wavy to flaser-bedded sand and mud. Barrier island accretion in the vicinity of inlets often involved flood channel switching; marginal flood channel deposits could thus comprise a significant portion of the barrier island lithosome in the vicinity of inlets. Distally, wave-formed swash platform deposits dominate the ebb-tidal delta sequence. These are characterized by very well sorted, fine-grained sand; planar bedding; landward-oriented crossbeds; coarse shell-hash layers; and extensively burrowed zones. Swash platform deposits interfinger with shoreface deposits laterally and at depth. Distal ebb-tidal delta deposits are thus relatively thin and have an overall coarsening-upward grain-size trend. (28 refs)

Isphording, W. C. 1987. Mobile Bay: The right estuary in the wrong place. (See complete entry in Section IV.)

Jarrett, J. T., and Hensley, J. M. 1988. Beach fill and sediment trap at Carolina Beach, North Carolina. (See complete entry in Section VIII.)

Jiaju, L., and Jingchaeo, Z. 1983. Siltation study of some extension projects of the Lianyun Harbour. In *International conference on coastal and port engineering in developing countries,* 20-26 March 1983, Colombo, Sri Lanka, II:1139-1147. Colombo, Sri Lanka: Conventions (Colombo) Ltd.

The coast and beach erosion and river sediment transport along a coastal line of about 200 km near the Lianyun Harbor show neither the river sediment transport nor the coast and beach erosion can bring a large amount of sediments into the Lianyun Harbor to cause siltation problem. The harbor siltation is caused mainly by suspended load moving back and forth on the shoal near the harbor. Based on the laws of the sediment movement caused by the combined acting forces of wind wave and tidal current and on the measured siltation data of the existing harbor, a method is presented calculating the basin siltation thickness of the Lianyun Harbor with consideration of the characteristics of the harbor layout and the effect of the shoal within the harbor on the basin siltation. (4 refs)

Johnson, B. H., Boyd, M. B., and Keulegan, G. H. 1987. A mathematical study of the impact on salinity intrusion of deepening the Lower Mississippi River navigation channel. (See complete entry in Section VI.)

Jones, D. G., Miller, J. M., and Roberts, P. D. 1984. The distribution of ^{137}Cs in surface intertidal sediments from the Solway Firth. (See complete entry in Section IV.)

Jones, M. R. 1987. Surficial sediments of the western Gulf of Carpentaria, Australia. *Australian Journal of Marine and Freshwater Research* 38(1):151-167.

Modern sedimentation in the Gulf of Carpentaria is confined principally to marginal areas in water depths of less than 50 m. Within this zone, the distribution of sediments is irregular, being controlled by proximity to sediment sources and degree of exposure to waves and tidal activity. This is particularly so in the western gulf, where fluvial sediments supplied to Limmen Bight have been transported by waves and tides northwards beyond that embayment to accumulate in the sheltered environment of Blue Mud Bay. Limmen Bight is exposed to the southeasterlies, which produce sufficient wave action in the nearshore zone to prevent the widespread deposition of fine-grained terrigenous sediments. As a result, relict sand deposits occupy much of the floor of Limmen Bight in areas shallower than about 25 m. In deeper areas, terrigenous muds are deposited at a low rate over relict fluvial and marine sediments. The relict deposits accumulated in continental and nearshore marine environments during low-sea-level periods of the late Pleistocene. (14 refs)

†**Jordan, T. E., and Valiela, I.** 1983. Sedimentation and resuspension in a New England salt marsh. *Hydrobiologia* 98(2):179-184.

Particulate matter in a salt marsh can undergo repeated sedimentation and resuspension. Sedimentation measured with sediment traps increases with tidal amplitude in areas with fast tidal currents, but is unaffected by tidal amplitude in areas with slow currents. The total sedimentation of particulate nitrogen in areas with slow tidal currents is three times as large as the gross tidal exchanges of particulate nitrogen between the marsh and coastal waters. Net tidal export of particles by the marsh suggests that sedimentation is more than offset by resuspension. Resuspension of fine (4-40 μm) particles occurs early in the flood tide in tidal creeks with slow currents. This resuspension does not increase with tidal amplitude, suggesting that it is not caused by tidal currents.

†**Jouanneau, J. M., and Latouche, C.** 1981. The Gironde Estuary. (See complete entry in Section VI.)

Kang, H. J., and Chough, S. K. 1982. Gamagyang Bay, southern coast of Korea: Sedimentation on a tide-dominated rocky embayment. *Marine Geology* 48(3/4):197-214.

Layered sediment sequences, up to 30 m thick, overlie an acoustic basement of Cretaceous tuffs in the Gamagyang Bay, a shallow postglacial embayment of approximately 150 km^2 in area on the southern coast of the Korean Peninsula. Sediments consisting mainly of terrigenous and bioturbated mud, tend to accumulate, at a rate of more than 134 cm/1,000 years, more in the central part of the bay than on the margins. Sedimentation has been influenced dominantly by strong tidal currents (up to 2.5 knots) resulting in numerous depressions (or moats) in the vicinity of islands and points. The sedimentary sequences of the moats are either depositional or depositional-erosional in origin. Acoustic basement lies deeper in the central axis of the bay, following the buried paleovalleys. Here the thick sediments contain probable gas encountered on Uniboom records characterized by the impedance of acoustic penetration. The existence of mid-reflectors above the acoustic basement suggests that the Gamagyang Bay was subaerially exposed during the last glacial period prior to about 4500 years BP. (20 refs)

Kawara, O. 1988. Study on the seasonal variation of surface sediment composition in estuaries. *Water Science and Technology* 20(6/7):123-132.

The purpose of this study, as the first step toward clarifying the pollutant transport mechanism of sediments, is to clarify the characteristics of the seasonal changes of surface sediment composition in estuaries based on observation. Remarkable seasonal variations are found in the particle size distributions and the concentrations of the constituents of the surface sediments, though the patterns of the variations are different in each estuary observed. The seasonal variations of the concentrations show good correspondence to those of the particle size distributions. One cause of the seasonal variation is the variation of river discharges. When the sediment size in the Asahi River Estuary, Okayama prefecture, became finer, the freshwater inflow to the estuary was about 2.5-3.5 times as much as ordinary water runoff (100-150 m^3/sec) and the change was completed in about 10 days. On the other hand, the change to coarser

sediment was completed in a day, by the inflow of over 400 m^3/sec. (12 refs)

Kelly, L. R., and Andrews, J. C. 1985. Numerical models for planning coastal circulation studies. (See complete entry in Section VI.)

Kendrick, M. P., Derbyshire, B. V., and Stevenson, T. A. 1985. Harbor siltation - Physical model and computational studies to establish present cause and predict post-development siltation rates. (See complete entry in Section VI.)

Kennedy, V. S., ed. 1984. *The estuary as a filter.* (See complete entry in Section VI.)

Kenyon, N. H. 1970. Sand ribbons of European tidal seas. *Marine Geology* 9(1):25-39.

Ribbons of sediment, up to 15 km long and up to 200 m wide, extend parallel to the bed-load transport paths of the tidal currents. The ribbons have been found by the side-scan asdic method in most of those areas of the sea floor around the British Isles where tidal currents have maximum near-surface velocities of 2 knots or more. The four types of ribbons, distinguished by their form, are related to tidal current velocity and supply of sand. Underwater photographs taken in a sand ribbon zone reveal bodies of shelly sand usually too thin to mask completely the underlying coarse material, but sometimes thick enough for the formation of small-scale bed forms including ripple marks and sand shadows. There is a variety of underlying coarse material and locally there are accumulations between the sand ribbons of the more durable shells that may be more readily preserved in ribbon form than the sand itself. (22 refs)

Kerchaert, P., Roovers, P. P. L., Noordam, A., and De Candt, P. 1986. Artificial beach nourishment on Belgian East Coast. *Journal of Waterway, Port, Coastal and Ocean Engineering,* ASCE, 112(5):560-571.

For several decades, the Belgian East Coast has posed problems of a sedimentological nature. Off the coast, a gully (called "Appelzak") has developed to a depth of 8 m below low water and has shifted dangerously near the existing sea dike, causing severe beach erosion. In 1976 the Belgian Government decided to sizably enlarge the outer harbor of Zeebrugge seaward to a distance of 3.5 km from the coast, and to proceed with a significant beach restoration of about 8.5 million m^3 of sand. An extensive observation program is being carried out to study beach changes and to indicate unexpected developments, so that countermeasures can be taken in good time. Results of observations over the period June 1979-February 1981 are examined using survey data from bathymetric sounds, aerial photogrammetry, and terrestrial beach measurements. (1 ref)

†**Kershaw, P. J.** 1989. An investigation of factors influencing the concentration of trace metals in the bottom sediments of the Forth Estuary. Ph.D. diss., University of Dundee, UK.

In this study a combination of analytical techniques has been used to investigate the factors influencing the concentration of certain trace elements in the bottom sediments of the Forth Estuary. A preliminary survey, using standard grain-size analysis and Z-ray fluorescence techniques, established that high metal concentrations were associated with fine-grained sediments. Concurrent with a decrease in grain size was an increase in the clay mineral content, and an understanding of the structure and behavior of clay minerals and clay suspensions was considered to be an essential prerequisite. A series of chemical pretreatments was applied to permit the compete disaggregation of clay suspensions and a large bulk sample was size-fractionated. The mineralogy of the size fractions was investigated by X-ray diffraction analysis. An unsuccessful attempt was made to extract specific clay minerals for use as reference standards. Analyses of individual grains and groups of grains were performed using a transmission electron microscope, equipped with an Si(Li) detector, both for mineral identification and detailed chemical analyses in particular monitoring the distribution of potassium in illite grains. The size-fractionated samples were also analyzed for a number of trace elements. It became clear that certain trace elements had a specificity for particular minerals whereas the distribution of others was solely dependent on the overall grain size of the specimens. These findings were supported by evidence from leaching experiments to assess the relative bonding strengths of each element. In conclusion, differences in mineralogy may exert a significant control on the distribution and concentration of specific trace elements in estuarine sediments.

Kilset, K., and Heibert, A. 1988. Evaluation of the "Fugacity" (FEQUM) and the "EXAMS" chemical fate and transport models: A case study on the pollution of the Norrsundet Bay (Sweden). (See complete entry in Section VI.)

Kineke, G. C., and Sternberg, R. W. 1989. The effect of particle settling velocity on computer suspended sediment concentration profiles. (See complete entry in Section VII.)

Kineke, G. C., Sternberg, R. W., and Johnson, R. 1989. A new instrument for measuring settling velocities in situ. (See complete entry in Section VII.)

King, C. J. H. 1980. A small cliff-bound estuarine environment: Sandyhaven Pill in South Wales. *Sedimentology* 27(1):93-105.

Sandyhaven Pill is a "drowned valley" type of estuary. Thus the deposits differ from most other described estuarine deposits which are of "tidally influenced river" type. The surface sediments may be divided broadly into wave-dominated deposits, tide-dominated deposits, deposits related to marginal cliff collapse, and river-dominated deposits. Over a 29-day period, reduction in wave height was reflected in wave-dominated areas by shoreward movement of some subenvironment boundaries and by improved definition of symmetrical ripples. The tidal cycle had only a limited effect on the tide-dominated sediments. The most reliable indicators of estuary trend are channels and asymmetrical ripples; but coring shows that ripples and other minor structures are rarely preserved. Heavy mineral analysis indicates that most of the estuarine sand came from offshore. (28 refs)

King, I. P., Granat, M. A., and Ariathurai, C. R. 1986. An inundation algorithm for finite element hydrodynamic and sediment transport modeling. (See complete entry in Section VI.)

Kjerfve, B. 1978. Bathymetry as an indicator of net circulation in well mixed estuaries. (See complete entry in Section I.)

Knebel, H. J. 1989. Modern sedimentary environments in a large tidal estuary, Delaware Bay. (See complete entry in section VIII.)

Knebel, H. J., Fletcher, C. H., III, and Kraft, J. C. 1988. Late Wisconsinan—Holocene paleogeography of Delaware Bay; A large coastal plain estuary. (See compete entry in Section VIII.)

Koutitas, C. G. 1986. Coastal circulation and sediment transport. In *River sedimentation*, Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:310-322. University, MS: University of Mississippi.

Numerical modelling of coastal bed morphology evolution is a major challenge to modern engineers. A classification of the mathematical models of sediment initiates this study. Criticism is exercised on the models using local transport formulas without consideration of inertial effects. An advanced model for circulation over and sedimentation in a dredged trench is subsequently presented. The importance of the detailed description of the circulation for the prediction of sedimentation patterns in coastal basins is illustrated via a case of wind-generated circulation and sediment transport. The qualifications and shortcomings of the existing 2DH models, for the wind waves generated circulation and sediment transport in the refraction and breakers zone of coastal areas, in connection to coastal structures, are discussed and further research orientations are proposed. (27 refs)

Kranck, K. 1984. The role of flocculation in the filtering of particulate matter in estuaries. In *The estuary as a filter*, ed. V. S. Kennedy, 159-175. Orlando: Academic Press.

The structuring of suspended particulate matter in estuaries into flocculated settling entities is described and discussed. A hierarchy of three particle distribution types is described: In situ distributions contain abundant large low-density fragile aggregates (macro-flocs) with high settling rates, the formation of which is promoted by low turbulence and high particulate concentrations. During periods of high currents in nature and during shipboard and laboratory sample handling, these macro-flocs break up into more stable distributions of smaller flocs which are the basic building blocks of the larger units. Laboratory oxidation of organic matter and disaggregation of aggregates allow the size analysis of individual single mineral grain distributions for purposes of direct comparison between bottom and suspended sediment spectra. The constituent grain-size distribution of the inorganic component of a floc replicates the grain size of the suspension as a while. The diverse grain size and chemical nature of the organic matter make its flocculation kinetics more complicated. Past laboratory experiments have indicated the existence of organic-inorganic proportions optimum for flocculation. This is substantiated by ash-loss data from three estuaries with different relative inputs of organic and inorganic matter. The particulate matter in each was dominated by similar organic-inorganic proportions (65-75 percent organic matter by volume) indicating that the component in excess of this value

had been preferentially exported from the estuary. Settling of suspended sediment as macro-flocs and near-bottom break-up and resuspension of floc fragments control the very dynamic equilibrium between particle trapping and particle flushing in estuaries. (44 refs)

Kuo, C. Y., and Talay, T. A. 1986. Characteristic vector analysis of remote sensing data for estuarine sediments. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:612-623. University, MS: University of Mississippi.

Application of the technique of characteristic vector analysis to remote sensing estuarine sediment data is demonstrated. Reflectance spectra from bottom sediments collected from the Bailey Bay and the Bermuda Hundred on the James River, Virginia, were measured in the laboratory. The analysis resolves the measured radiance signals into eigenvectors and associated scalar coefficients to identify and quantify the sediment as a single constituent and a mixture. (10 refs)

Lambiase, J. J. 1980. Hydraulic control of grain-size distributions in a macrotidal estuary. *Sedimentology* 27(4):433-446.

The Avon River Estuary of Nova Scotia was studied with the intention of analyzing the relations between grain size distributions and hydraulics. Sediment transport paths in the estuary were determined from bed form migration directions and the computed net sediment transport per tidal cycle using Engelund and Hansen's formula. The areal distribution of the transport paths, combined with the differential transport rates of each grain population, produces hydraulic sorting. Hydraulic sorting causes coarse sediment to be excluded from the estuary head and creates the inverse relationship between current speed and mean grain size. (44 refs)

Lavelle, J. W., Massoth, G. J., and Crecelius, E. A. 1986. Accumulation rates of recent sediments in Puget Sound, Washington. *Marine Geology* 72(1/2):59-70.

Sixteen profiles of unsupported ^{210}Pb activity from long cores along the axis of the Main Basin of Puget Sound show that bottom sediments are accumulating at rates of 0.26 ± 0.03 to 1.20 ± 0.16 g cm^{-2} year^{-1}. These rates and seven others published earlier suggest that highest accumulation occurs nearly midway along the length of this tidal-current-dominated basin. Bioturbated surface layers of cores are as deep as 40 cm, but biologic mixing rates are poorly determined. Individual ^{210}Pb accumulation rates along the axis of the Main Basin range from approximately one to five times greater than the predicted areal-average accumulation rate based on estimates of recent sediment input from adjoining rivers and shorelines. (29 refs)

Leffler, M. W., Smith, E. R., and Mason, C. 1986. 1984 nearshore surveys and sediment sampling, Assateague Island, Maryland. (See compete entry in Section VIII.)

Lin, B. N., Han, Z. C., Sun, H. B., Zhou, J. D., He, S. L., and Wang, L. X. 1986. Two-D simulation of sediment transport and bed deformation by tides. In *River sedimentation*, Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:388-399. University, MS: University of Mississippi.

Two-dimensional numerical simulation of concentration of sediment and bed deformation has been carried out for a well-mixed estuary under the condition of nonequilibrium transport of sediment. The computed concentration hydrographs follow observed data reasonably well. The computed changes in bathymetry over five tides are qualitatively verified by the change in bed topography observed from 1972 to 1982 in the sense that the locations of deposition and erosion are generally similar. Due to lack of detailed data of tide and sediment for the 10-year period, detailed verification is, for the time being, impossible. (7 refs)

Lin, H.-C. J., and Martin, W. D. 1989. Newport News channel deepening study, Virginia; Numerical model investigation. (See complete entry in Section VI.)

Lin, P.-N., Huan, J., and Li, X. 1983. Unsteady transport of suspended load at small concentrations. *Journal of Hydraulic Engineering,* ASCE, 109(1):86-98.

When suspension is the predominant mode of sediment transport, an expression for the rate of bed changes may be introduced. This equation together with the momentum equation and the continuity equations of water and sediment constitute a set of four equations for four unknowns. Characteristic

directions can then be determined without solving a high-degree algebraic equation. The solution is further simplified by adopting a small-concentration approximation. Routing of suspended load with this method is applied to the Qiantang Estuary in Eastern China and rather close simulation has been achieved. (8 refs)

Liu, J. 1986. A study on the siltation in the approach channel with different alignments of the Lianyun Harbour. (See complete entry in Section VIII.)

†**Liu, J. T.-C.** 1987. Sediment patterns and shoreface bathymetry as a key to understanding shoreface dynamics: A case study of the south shore of Long Island, New York. (See compete entry in Section VI.)

Lowery, T. A., ed. 1987. *Symposium on the natural resources of the Mobile Bay Estuary.* (See complete entry in Section V.)

Lung, W.-S. 1986. Advective acceleration and mass transport in estuaries. (See complete entry in Section I.)

†**McAnally, W.** 1981. Modeling: How and when to use. (See complete entry in Section VI.)

McAnally, W. H., Jr., and Stewart, J. P. 1982. Hybrid modeling of estuarine sedimentation. (See complete entry in Section VI.)

McAnally, W. H., Jr., Letter, J. V., Jr., and Thomas, W. A. 1986. Two and three-dimensional modeling systems for sedimentation. (See complete entry in Section VI.)

McCave, I. N. 1979. Tidal currents at the North Hinder Lightship, southern North Sea: Flow directions and turbulence in relation to maintenance of sand banks. (See complete entry in Section VIII.)

McLaren, P., and Little, D. I. 1987. The effects of sediment transport on contaminant dispersal: An example from Milford Haven. (See complete entry in Section IV.)

McLaren, P., and Powys, R. 1989. The use of sediment trends to assess the fate of dredged material. In *Dredging: Technology, environmental, mining;* Proceedings of WODCON XII, 2-5 May 1989, Orlando, Florida, 224-233. Irvine, CA: World Dredging Mining and Construction.

At the 1986 WODCON XI Conference (Brighton) a new concept was presented describing how patterns of net sediment transport can be determined by the proper interpretation of grain size distributions. The technique requires a grid of equally spaced samples collected over the area studied. These are analyzed for their complete grain size distribution, and net sediment transport is determined by assessing statistically particular changes in the distributions along selected sequences of samples. Since the Brighton Conference, this approach has been used in a large variety of engineering and environmental problems. This paper focusses on two examples from widely different environments. The findings at the first site, on the foreslope of the Fraser Delta in the Strait of Georgia, showed that the sediment regime is dominated by the Fraser River plume; and sediment, once deposited, underwent no further transport. At this location it was shown that the dredge material was no longer mobile and was not contributing to the contaminant loadings observed in the surrounding sediments. The analysis at the second site near Blackpool showed how a properly designed dredging program could be used as an effective means to prevent serious shoreline erosion. (4 refs)

McManus, J. 1986. Sediment transport patterns in the Tay Estuary, Scotland. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:517-524. University, MS: University of Mississippi.

This paper describes the sediment transport patterns found in the 50-km-long macrotidal Tay Estuary, Scotland, U.K., classifies the sediments, and describes their position. (22 refs)

Madden, C. J., Day, J. W., Jr., and Randall, J. M. 1988. Freshwater and marine coupling in estuaries of the Mississippi River deltaic plain. *Limnology and Oceanography* 33(4, part 2):982-1004.

The estuaries of Louisiana's Mississippi River deltaic plain (MRDP) exhibit sharp physical and biological contrasts due to their different successional stages in delta development. The Atchafalaya-Fourleague Bay complex is a young deltaic system with high freshwater and sediment inputs. The area has been undergoing rapid land building since 1973. The Barataria Basin estuary occupies a deltaic land mass which formed over 2000 B.P. and has since been isolated from riverine inflow and sediment renewal. It is

experiencing a high rate of land loss. A comparison of these estuaries offers an excellent opportunity to observe coupling of freshwater and marine environments at the extremes of their scale of interaction. In the Atchafalaya system, riverine input is highly seasonal, and the estuary receives most of its sediment input and high loadings of nutrients during spring. However, high turbidity and colder temperatures limit phytoplankton productivity during this time. During the period of low flow in summer and fall, Gulf of Mexico waters dominate Fourleague Bay and provide an important interlude of clearer water when riverborne and regenerated nutrients can be maximally exploited by phytoplankton. The Barataria Basin estuary does not exhibit the strong seasonality found in Fourleague Bay. Barataria receives no direct riverine input, and the main hydrologic inputs are precipitation and upland runoff. The Barataria estuary depends on organic production and resuspended lake bottom sediments for much of the marsh building that occurs. Therefore, in the Barataria system, tides, Gulf water levels, and wind-driven resuspension are much more important to maintenance of the wetland. The upper basin is heavily impacted by nutrient runoff from urban and agricultural areas and is eutrophic. Lower Barataria Basin remains in a more natural state. Despite being at opposite ends of the delta life cycle, both estuaries are highly productive and perform similar functions as important nursery grounds for juvenile marine and estuarine fishes. (94 refs)

Marsden, M. A. H., Mallett, C. W, and Donaldson, A. K. 1979. Geological and physical setting, sediments and environments, Western Port, Victoria. *Marine Geology* 30(1/2):11-46.

This paper assesses the physical and geological features of Western Port, Australia, including the geological evolution, Holocene morphology, sediment distribution, sedimentation patterns, and depositional environments. Interpretations were based on data from field mapping, aerial photographs, sediment sampling, depth profiling at selected sites, and limited scuba inspection. The complex shape of the bay is determined by geological factors, and only minor stream discharge and associated sediment input occur. Tidal activity is dominant and estuarine circulation is not well developed. Eight intertidal and subtidal environments have been recognized. Net long-term paths of sand transport and deposition and zones of ebb dominance and flood dominance were delineated within the bay and suggest a landward reworking by tidal processes. The extensive intertidal environments show variable sediment distribution patterns of sand and mud, controlled by salt marsh, mangroves, and dense intertidal and subtidal seagrass meadows. Sand is concentrated mainly in tidal channels and associated subtidal offshore banks. Mud is dominant in the embayment head and in isolated intertidal areas, except where autochthonous sand is abundant. Suspended sediment is active in the channels, particularly near mud-rich intertidal areas. (30 refs)

Matondo, J. I. 1989. Beach erosion protection methods: Case study of Dar City, Tanzania. (See complete entry in Section V.)

Mehta, A., and Maa, P.-Y. 1986. Waves over mud: Modeling erosion. (See complete entry in Section VI.)

Mehta, A. J., Partheniades, E., Dixit, J. G., and McAnally, W. H. 1982. Properties of deposited kaolinite in a long flume. (See complete entry in Section VI.)

†Mizumura, K., and Shirashi, N. 1981. Stochastic onshore-offshore sediment transport. In *Fifth Australian conference on coastal and ocean engineering 1981 on offshore structures,* 25-27 November 1981, Perth, Australia, 219-224. Barton, Australia: The Institution of Engineers, Australia.

An analysis of two-dimensional coastal changes is presented for sandy beaches. Particular regard is given to the modelling of sediment transport processes. In contrast to previous theories that use only deterministic approaches, the present theory predicts the occurrence of sand erosion and transport with probability theories.

†Morelock, J., Grove, K., and Hernandez, M. L. 1983. Sedimentary and physical dynamic processes of selected estuaries and river inlets of Puerto Rico. Mayaguez, PR: Puerto Rico University, Department of Marine Sciences.

Sediment deposition on the Anasco-Mayaguez shelf reflects sea level rise over a subaerially developed surface interacting with carbonate reef and river sediment sources. Wave and current patterns have played a role in distribution of the sediments. Coral reefs formed on local highs and contributed skeletal components to the sediment. Deepening sea level changed the character of the terrigenous deposits and reef sediments. As sea level approached the present level, patterns of modern sediment deposition began.

Müller, K.-D., and Schwarze, H. 1988. Some studies to reduce sedimentation in a port on a tidal river. *Water Science and Technology* 20(6/7):253-261.

Sedimentary material containing harmful substances dredged from seaports has become an increasing problem over the past few years. A main part of the sediment, mostly silt, contaminated with heavy metals settles out in the region of harbor entrances. The reasons for this problem are explained. For a huge harbor basin of the Port of Hamburg, investigations in a physical model had been carried out to find measures for reducing the sediment intrusion into the harbor basin. The article shows possible reconstructions of the harbor entrance in consideration of the navigation and their expected influence on the sedimentation transport into the harbor basin. (7 refs)

Murphy, P. P., Bates, T. S., Curl, H. C., Jr., Feely, R. A., and Burger, R. S. 1988. The transport and fate of particulate hydrocarbons in an urban fjord-like estuary. (See complete entry in Section VIII.)

Nadeau, J. E., and Hall, M. J. 1988. Distribution patterns of metals in sediments of the Great Sound Complex, New Jersey. *Marine Geology* 82(1/2):113-122.

Fifty-four bottom grab samples and six 1-m cores were collected from a back-barrier lagoonal complex on the mixed energy, tide-dominated coastline of southern New Jersey. The lagoon is connected to the ocean through tidal inlets to the north and south, and is transected by the Intracoastal Waterway. Samples were wet sieved to separate the <63-μm fraction which was digested and analyzed for silver, arsenic, cadmium, cobalt, copper, iron, mercury, lead, and zinc concentrations. Metals are commonly associated with the <63-μm fraction and/or organic fractions sediments; however, in Great Sound both are more widely distributed than the area of high metal concentration. The areal distribution pattern of metals, supported by Roy's Maximum Root statistical evaluation, indicates that the avenue of metal access (except for iron) to Great Sound is via Great Channel with the more likely route through Cresse Thorofare and/or via Gull Island Thorofare after the bifurcation of Great Channel. Analysis of cores revealed two vertical distribution patterns: (a) cores recovered adjacent to the Intracoastal Waterway show a decrease in concentration with depth, while (b) cores from sites removed from the Intracoastal Waterway show multiple peaks interpreted to be caused by dredging and/or tidal redistribution of sediments. Access of iron and organics to Great Sound could not be determined. (25 refs)

Naik, A. S., Kanhere, V. N., and Vaidyaraman, P. P. 1983. Effect of salinity on siltation in the Cochin Port. (See complete entry in Section III.)

†Nair, R. R. 1984. The Indus paradox. (See complete entry in Section I.)

Nichols, M. M. 1986. Storage efficiency of estuaries. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:273-289. University, MS: University of Mississippi.

The storage efficiency of different estuaries is compared with respect to key factors that can be quantified and that vary within the region. It was found that storage efficiency in northern estuaries is encouraged by low flushing velocity and high volumetric capacity relative to river inflow. The long-term rise of sea level relative to the land tends to offset sediment accumulation and maintain or increase capacity. Within the range of estuaries considered, efficiency generally increases as the flow ratio decreases. This trend suggests the estuarine circulation in partially mixed systems is important both in trapping fluvial sediment and in transporting sediment landward from the sea. (37 refs)

Nihoul, J. C. J., and Jamart, B. M., ed. 1987. *Three-dimensional models of marine and estuarine dynamics.* (See complete entry in Section VI.)

Oenema, O., and DeLaune, R. D. 1988. Accretion rates in salt marshes in the Eastern Scheldt, Southwest Netherlands. 26(4):379-394. (See complete entry in Section III.)

Officer, C. B., Lynch, D. R., Setlock, G. H., and Helz, G. R. 1984. Recent sedimentation rates in Chesapeake Bay. In *The estuary as a filter,* ed. V. S. Kennedy, 131-157. Orlando: Academic Press.

Nonlinear parameter estimation techniques were applied to obtain optimum values and confidence intervals for mass sedimentation rates in Chesapeake Bay from ^{210}Pb, ^{137}Cs and $^{239,240}Pu$ geochemical tracer profiles. The results show high sedimentation rates of around 0.3-1.2 gm $cm^{-2}year^{-1}$ for the upper bay, modest sedimentation rates of

0.1-0.3 gm $cm^{-2}year^{-1}$ for the middle bay, and modest to high sedimentation rates of 0.1-0.8 gm $cm^{-2}year^{-1}$ for the lower bay. The principal source for the upper bay is the Susquehanna River discharge and that for the lower bay is the ocean and lower bay environment. In terms of total sediment budget the results are in agreement with published evidence that episodic sedimentation events are an important feature of the bay system. (27 refs)

Onishi, Y., and Thompson, F. L. 1986. Sediment and contaminant transport in a marine environment. (See complete entry in Section VI.)

Otsubo, K., and Muraoka, K. 1985. Resuspension rate function for cohesive sediments in stream. *Journal of Hydroscience and Hydraulic Engineering* 3(2):1-13.

In shallow lakes or estuaries, cohesive bottom sediments undergo repeated deposition and resuspension. They are suspended by current and wave motion, and dissolved nutrients in the bottom sediment pores are released into the upper water body. To estimate the released nutrient, it is essential to determine the amount of resuspended sediment. In this paper, the resuspension rate is studied experimentally and theoretically. Dimensional analysis was applied to experimental results to obtain the dimensionless function of the resuspension rate against bed shear stress. Furthermore, a physical model was made to estimate the resuspension rate. Cohesive sediments are thought to be dislodged from the bottom by three different styles of detachment: sliding, lifting, and rolling. It was determined that for cohesive sediments sliding detachment predominates. (10 refs)

Otvos, E. G. 1981. Barrier island formation through nearshore aggradation--Stratigraphic and field evidence. (See complete entry in Section I.)

Oyegoke, E. S., Osoba, E. B., Oladapo, O. O., Uzochukwu, B. N., and Ibrahim, A. 1983. Coastal erosion problems in Nigeria and some measures adopted over the years for their solution. (See complete entry in Section V.)

Özsoy, E. 1986. Ebb-tidal jets: A model of suspended sediment and mass transport at tidal inlets. (See complete entry in Section VI.)

Páez-Osuna, F., Botello, A. V., and Villanueva, S. 1986. Heavy metals in Coatzacoalcos Estuary and Ostion Lagoon, Mexico. (See complete entry in Section IV.)

Parchure, T. M., and Mehta, A. J. 1985. Erosion of soft cohesive sediment deposits. *Journal of Hydraulic Engineering,* ASCE, 111(10):1308-1326.

Erosion behavior of soft cohesive sediment deposits has been investigated in laboratory experiments. Such deposits are representative of the top, active layer of estuarial beds. An experimental procedure involving layer-by-layer erosion under a range of bed shear stresses τ_b of successively increasing magnitude was utilized. Interpretation of the resulting concentration-time data together with bed density profiles yielded a description of the variation of the bed shear strength, τ_s, with depth as well as an expression for the rate of surface erosion. In general, τ_s increased with depth and was also influenced by the type of sediment, bed consolidation period, and salinity. The rate of erosion was found to vary exponentially with $(\tau_b - \tau_s)^{1/2}$. In modeling estuarial bed erosion, it is essential to take these characteristics of τ_s and the rate of erosion into account. (17 refs)

Parker, W. R. 1988. On the role of fine sediment behaviour in pollutant transfer modelling. *Water Science and Technology* 20(6/7):175-182.

The role played by fine cohesive sediment in the transport and recycling of pollutants arises from the often reversible partition of pollutants between the dissolved phase and surface sorbed phase. Adequate prediction requires that a realistic understanding of the physical behavior of the fine sediment population of an area is coupled with the kinetics of the sorption/desorption equilibria at crucial stages in the fine sediment transport cycle. This paper examines the physical basis underlying the prediction of fine sediment transport, identifying processes and phenomena which are important in affecting predictions. Parameterizations of source and sink terms are seen to be areas of great uncertainty, and model calibration requires the deployment of new, but available, technology. (31 refs)

Paterson, D. M. 1989. Short-term changes in the erodibility of intertidal cohesive sediments related to the migratory behavior of epipelic diatoms. *Limnology and Oceanography* 34(1):223-234.

The surface stability of intertidal cohesive sediments maintained in a laboratory tidal ecosystem was examined in relation to the migratory behavior of epipelic diatoms. Stability was measured by a new portable device—a cohesive strength meter. Diatom-inhabited sediments increased significantly in surface stability over 7.3-hour tidal exposure as compared

with consolidated and unconsolidated control sediments. Low-temperature scanning electron microscopy showed an extensive extracellular matrix throughout the surface of diatom-inhabited sediments. This matrix was considered to consist mainly of mucopolysaccharides produced by diatoms as part of their locomotive mechanism. A matrix of very fine strands (possibly of bacterial origin) was found on the consolidated control sediment but had little effect on stability. Surface stability imparted by the mucilage produced by epipelic diatoms decayed after the return of the tide, but when dense populations of diatoms were present (10^6 diatoms cm^{-2}) some residual stability remained after a full tidal inundation. (29 refs)

Pejrup, M. 1986. Parameters affecting fine-grained suspended sediment concentrations in a shallow micro-tidal estuary, Ho Bugt, Denmark. (See complete entry in Section VI.)

Pejrup, M. 1988. Suspended sediment transport across a tidal flat. *Marine Geology* 82(3/4):187-198.

Many investigations have shown that most of the suspended sediment supplied to the Wadden Sea originates from the North Sea. Based on measurements of current velocity, depths, and suspended sediment concentrations in the Danish part of the Wadden Sea, computations indicate, however, that suspended sediment is in fact exported to the North Sea. The reason for this discrepancy is twofold: firstly, measurements have been carried out mainly in tidal channels where the largest amounts of water and suspended sediment are in the main transported during ebb periods. Secondly, computation of net transport in an estuarine environment such as the Wadden Sea always suffers from the difficulty that net transport within each single tidal period is of the same order as the uncertainty of the transport rates during ebb and flood periods, respectively. The first problem can be dealt with if measurements are carried out in both tidal channels and over the tidal flats. The second problem can be solved by collecting time-series instead of discrete measurements because accumulation of the transport rates found for successive tidal periods will neutralize the relatively large random error. In this paper, time-series of suspended sediment flux across a tidal flat covering a full spring neap tidal cycle are presented. They showed net transport of suspended sediment in a landward direction which is mainly caused by flocculation of fine-grained sediment during periods of high concentration level. During such periods the field settling velocities of suspended sediment are so large that the settling- and scour-lag processes can be effective. (39 refs)

Perillo, G. M. E., and Ludwick, J. C. 1984. Turbulence measurements over a sand wave in Lower Chesapeake Bay, Virginia. (See complete entry in Section VIII.)

Pilarczyk, K. W., Misdorp, R., Leewis, R. J., and Wisser, J. 1986. Strategy to erosion control of Dutch estuaries. (See complete entry in Section V.)

†Pirie, D. M., and Steller, D. D. 1977. California coastal processes study--Landsat II, final report. (See complete entry in Section VIII.)

Pizzuto, J. E. 1986. Barrier island migration and onshore sediment transport, southwestern Delaware Bay, Delaware, U.S.A. *Marine Geology* 71(3/2):299-325.

A detailed sediment budget for part of a rapidly migrating (3 m $year^{-1}$) barrier system of southwestern Delaware Bay demonstrates that longshore drift and other principal sources of sediment are insufficient to balance the sediment budget during 1926-1981. Changes in bathymetry from 1964 to 1984 indicate that erosion is occurring in shallow areas outside the surf zone. If approximately half of the sediment eroded offshore is transported onto the beach, the sediment budget balances. These results suggest that sand and gravel are supplied to the barriers of the study area from offshore. Several processes probably combine to carry sediment landwards. Tidal currents are weak, and probably rarely entrain sediment without the assistance of waves. Once entrained, sediment may be carried onshore by the combined influence of dominant ebb-tidal currents and frequent northwest winds. This process is probably also aided by a residual onshore shear stress associated with 2nd-order Stokes waves. (43 refs)

Pommeruy, M., Cormier, M., Brunel, L., and Breton, M. 1987. Bacterial flora studied in a Brittany Estuary (Elorn, rade de Brest, France) (Étude de la flore bactérienne d'un estuaire breton (Élorn, rade de Brest, France). (See complete entry in Section IV.)

Ports, M. A., ed. 1989. *Hydraulic engineering*. (See complete entry in Section I.)

Poulet, S. A., Chanut, J.-P., and Morissette, M. 1986. Size spectra of particles in the estuary and Gulf of Saint Lawrence; I: Variations with space (Étude des spectres de taille des particules en

suspension dans l'estuaire et le golfe du Saint-Laurent. I. Variations spatiales). *Oceanologica Acta* 9(2):179-189 (In French).

Among 1202 samples of suspended matter within the 1- to 200-μm size range, measured with a Coulter counter in April/May and September 1974 in the estuary and gulf of Saint Lawrence, five groups of particle size spectra were identified by principal component analysis. Particle spectra in groups 1, 2, and 3 were observed in estuarine waters, whereas particles in groups 4 and 5 were observed in marine waters. From the variations detected within or among the five groups, it is assumed that particles in group 3 are probably intermediate between particles of estuarine and marine origins. (44 refs)

Puls, W., and Kuehl, H. 1986. Field measurements of the settling velocities of estuarine flocs. (See complete entry in Section VIII.)

Ramsay, P. J., Cooper, J. A. G., Wright, C. I., and Mason, T. R. 1989. The occurrence and formation of ladderback ripples in subtidal, shallow-marine sands, Zululand, South Africa. (See complete entry in Section I.)

†**Ramsey, K. W.** 1988. Stratigraphy and sedimentology of a late Pliocene intertidal to fluvial transgressive deposit: Bacons Castle formation, upper York-James Peninsula, VA. Ph.D. diss., University of Delaware, Newark.

The Bacons Castle formation is a tidal to fluvial transgressive unit deposited on the Virginia Coastal Plain during the late Pliocene. Lithofacies recognized within the Bacons Castle form associations that represent distinct depositional systems. Association I consists of sand and mud deposited in a tidal-flat and estuarine system along an embayed shoreline. Association II consists of pebble and cobble gravel and gravelly sand that grade upward into sandy mud that was deposited in a fluvial to estuarine system. Areal distribution of the associations I and II and their distinctive lithologies allow for subdivision of the Bacons Castle into two members, the Barhamsville and Varina Grove Members, respectively. Deposition occurred on a surface dissected by rivers ancestral to the modern James and Pamunkey rivers. A regolith and/or soil horizon on the underlying Yorktown formation indicates that the Yorktown was exposed subaerially prior to Bacons Castle deposition. During Bacons Castle transgression, the antecedent topography was flooded. Depositional environments were localized and lithofacies influenced by the configuration of the topography. Antecedent highs provided shelter for tidal flats from wave and current activity until overtopped by transgression and environments migrated landward. Fluvial deposition was localized to antecedent valleys until the valleys were filled after which the fluvial system migrated unrestricted. The Bacons Castle rests unconformably on the late Pliocene Yorktown and Chowan river formations. Based on its transgressive nature and stratigraphic position, the age of the Bacons Castle is estimated to be between 2.3 and 2.1 my, following initial Northern Hemisphere glaciation(s) during the late Pilocene. The composition and texture of the Bacons Castle indicate a source from the Valley and Ridge, Blue Ridge, and Piedmont. The coarse texture and alluvial architecture of the unit indicate high-discharge transport. Sediment textures and transport mechanism suggest a climatic influence of cold-climate mass wastage transported by rivers fed by snowmelt, runoff on frozen ground, or increased rainfall with interglacial climatic amelioration. The Bacons Castle represents evidence of the influence of late Pliocene climate on deposition within the Atlantic Coastal Plain.

Readman, J. W., Preston, M. R., and Mantoura, R. F. C. 1986. An integrated technique to quantify sewage, oil and PAH pollution in estuarine and coastal environments. (See complete entry in Section IV.)

Reed, D. J. 1988. Sediment dynamics and deposition in a retreating coastal salt marsh. *Estuarine, Coastal and Shelf Science* 26(1):67-79.

The local rate of relative sea level rise at Bridge Creek on the Dengie Peninsula in southeast Essex, England, is approximately 3 mm year^{-1}, but the salt marsh vegetation shows no sign of stress due to increased submergence indicating continued accretion of the marsh surface. Evidence from aerial photography shows that the marsh front has retreated by over 40 m since 1955. Monitoring of current velocity and suspended sediment concentrations over both spring and neap tides shows great variability in both the magnitude and direction of net flux. This is explained by changes in the velocity regime and the entrainment of sediment from within the creek system during certain tidal flow conditions. The accretion pattern on the marsh surface, measured over a 2-year period, indicates that sediment eroded from the marsh edge is locally more important in accretion than that delivered via the creek system. The dynamics of sediment within the marsh system as a

whole are examined, and their importance related to the maintenance of salt marshes in areas subjected to relative sea level rise. (31 refs)

Reinson, G. E. 1977. Tidal-current control of submarine morphology at the mouth of the Miramichi Estuary, New Brunswick. (See complete entry in Section I.)

Richards, D. R., and Clausner, J. E. 1988. Feasibility of sand bypassing systems for reducing maintenance dredging in the St. Marys River entrance channel. (See complete entry in Section V.)

†Richmond, B. M., Nelson, C. S., and Healy, T. R. 1984. Sedimentology and evolution of Ohiwa Harbour, a barrier-impounded estuarine lagoon in Bay of Plenty. (See complete entry in Section I.)

Rodda, J. C., and Jones, G. N. 1983. Preliminary estimates of loads carried by rivers to estuaries and coastal waters around Great Britain derived from the Harmonized Monitoring Scheme. *Journal of the Institution of Water Engineers and Scientists* 37(6):529-539.

Over the last 10 to 15 years, national systems for the monitoring of river water quality have been developed in a number of countries. Such initiatives have usually resulted from international collaborative exercises, for example the Global Environmental Monitoring System (GEMS); from the requirements of supranational bodies, such as the European Economic Community; or from the needs of governments for water data for their own policy and planning purposes. The Harmonized Monitoring Scheme is the British system for the routine collection, analysis, archiving, and publication of data on river water quality which commenced operation in 1974. Before that time most of the routine monitoring was undertaken for local or river basin purposes; hence there was no urgent and compelling reason for concern about differences in methods of sampling and analysis from one part of the country to another. However, such differences were recognized to be important to a national monitoring system, so an essential feature of the Harmonized Monitoring Scheme is the interlaboratory calibration program. This program is designed to produce comparable results of demonstrable accuracy so as to meet the objectives of the scheme, namely: (a) to enable estimates to be made in connection with the United Kingdom's obligations, of materials carried down rivers into estuaries; and (b) to enable long-term trends in river quality to be identified. This paper is concerned with the first of these objectives: it provides preliminary estimates of the loads of eight chemical determinands carried by the rivers draining Great Britain. It does not deal with discharges made directly to the sea. (27 refs)

Salomons, W., Schwedhelm, E., Schoer, J., and Knauth, H. 1988. Natural tracers to determine the origin of sediments and suspended matter from the Elbe Estuary. *Water Science and Technology* 20(6/7):89-102.

The clay mineral composition, the concentrations of carbonates, the proportions of carbon and oxygen isotopes in carbonates and organic matter as well as the concentrations of different elements have been used to determine the origin of several grain-size fractions of the sediment and the suspended matter from the Elbe Estuary. The clay mineral composition, especially the smectite-kaolinite proportion, demonstrated that solid aerial $\leq 2\mu$* from the North Sea is transported up the river, about 50 km beyond the average position of the salt wedge. As far as the fraction 2-20μ is concerned, the upward transport of North Sea material was proved by the calcite concentration, the calcium:strontium proportion in total particulates, and the isotopic composition of the carbonates, demonstrating a transport of at least 40 km beyond the marine water limit. The transport behavior of the grain size fraction 20-63μ could be determined by the hafnium concentration. In this case, the distance of the transport beyond the salt wedge was around 30 km. The isotopic composition of the carbonates confirmed the landward transport of this fraction. The organic matter in the coarser fractions was partly derived from debris of marsh vegetation. Due to the contribution of sources within the estuary, information obtained from the tracer pertained to the origin of the organic matter only. The results demonstrate the mixing between marine and fluvial sediments and transport of marine sediments past the salt wedge. This physical process occurs with chemical processes responsible for the observed decrease of pollutant concentrations in solid matter along the estuary. Additionally, the different amounts of the upstream transport distances of the investigated grain-size fractions support the hypothesis of settling and scour lag-induced particulate transport. (27 refs)

Santschi, P. H., Nixon, S., Pilson, M., and Hunt, C. 1984. Accumulation of sediments, trace metals (Pb,Cu) and total hydrocarbons in Narragansett Bay, Rhode Island. (See complete entry in Section IV.)

Schaffranek, R. W., and Baltzer, R. A. 1989. Implementation of a hydrodynamic model for the upper Potomac Estuary. (See complete entry in Section VI.)

Schmalz, R. A., Jr. 1986. Sediment transport management in the Columbia River entrance. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:364-370. University, MS: University of Mississippi.

The Columbia River entrance forms a portion of the border between the states of Washington and Oregon in the Pacific Northwest. The US Army Corps of Engineers maintains a deep-draft navigation channel from the entrance to Portland, Oregon, a distance of approximately 165 km. A methodology for developing a channel sediment transport management plan for reduction of maintenance dredging demands is outlined in the following steps: historical bathymetric survey data and channel cross sections are examined; features of the entrance and its interaction with the lower estuary are considered; short-term (event-oriented) numerical modeling requirements for predicting sediment transport into and out of the coastal channel system are developed; an approach for compositing a set of event-oriented model results to simulate system changes over a 1-year maintenance dredging cycle is presented; potential applications and extensions to the 50-year design period of coastal navigation channel projects of the composition approach in the previous step are investigated; in the concluding section, additional research work ongoing at the Coastal Engineering Research Center pertinent to sediment transport management of coastal navigation channels is presented. (16 refs)

Schubel, J. R., and Carter, H. H. 1984. The estuary as a filter for fine-grained suspended sediment. In *The estuary as a filter,* ed. V. S. Kennedy, 81-105. Orlando: Academic Press.

Estuaries function as "filters" for the signals they receive from the land and the sea. The nontidal residual circulation, tidal mixing, and estuarine geometry determine the efficiency of this filter for suspended sediment. Tidal currents provide energy for mixing salt water from the ocean with fresh water from the river. The resulting salinity distribution drives that part of the nontidal circulation caused by density differences, which in turn influences the salinity patterns and resulting density gradients. This feedback between salinity redistribution and gravitational circulation places a constraint (filter) on the range of variations in flow and salt concentration in the estuary. The nontidal circulation also controls the distribution and transportation of suspended sediment and the deposition of fine particles within the estuary. The distributions of salt and fine suspended matter control the behavior of many non-conservation constituents such as nutrients, radionuclides and some metals, their modes of occurrence and transport, and their reservoirs of accumulation. The result of these processes is that the estuary modifies significantly the strength and the form of the signals it receives from land and sea. Alteration of an estuary's gravitational circulation pattern by changing its freshwater input or its geometry modifies its filtering efficiency. In general, an estuary changes from being highly stratified toward being well-mixed, its filtering efficiency for land-derived constituents first increases to a maximum (in the partially mixed region) and then decreases. A simple kinematic model is used to demonstrate the relationship between estuarine type (gravitational circulation pattern) and filtering efficiency for Chesapeake Bay, USA. (53 refs)

Schubel, J. R., and Kennedy, V. S. 1984. The estuary as a filter: An introduction. In *The estuary as a filter,* ed. V. S. Kennedy, 1-11. Orlando: Academic Press.

The ability of estuaries to remove and to retain materials in suspension and in solution has important practical as well as scientific implications. It leads, or at least contributes in a significant way, to many of the most serious estuarine pollution and management problems with which we are confronted: the accumulation of contaminants in sediments; dredging and dredged material disposal, particularly of contaminated sediments; nutrient enrichment; dissolved oxygen depletion; degradation and loss of benthic habitat; loss of submerged aquatic vegetation; and many others. Fortunately, it also allows an amelioration of estuarine water quality despite high loading rates and promotes recycling of nutrients and organic matter and the maintenance of high rates of primary and secondary production. (10 refs)

Seabergh, W. C. 1976. Improvements for Masonboro Inlet, North Carolina. (See complete entry in Section V.)

Segar, D. A., Davis, P. G., and Stamman, E. 1984. A global comparison of contamination in populated

estuaries and coastal waters. (See complete entry in Section IV.)

Seng, L. T., Kwong, L. Y., Chye, H. S., Huat, K. K., Pheng, K. S., Hanapi, S., Meng, W. T., Legore, R. S., de Ligny, W., and Tan, G. T. 1987. Effects of a crude oil terminal on tropical benthic communities in Brunei. (See complete entry in Section IV.)

Sha, L. P. 1989. Sand transport patterns in the ebb-tidal delta off Texel Inlet, Wadden Sea, The Netherlands. *Marine Geology* 86(2/3):137-154.

Sand transport patterns in the ebb-tidal delta of Texel Inlet were studied using current and wave measurements, calculations of sediment transport rate, bed form orientations, dips of cross beds, and the morphological evolution. A qualitative picture of sand transport patterns was formed. Sand supplied from the North Sea and the adjacent coast is transported in and out through several neighboring flood- and ebb-dominated channels in the southwestern ebb delta. Along the seaward margin of the ebb-tidal delta of Texel Inlet, sand is transported in both directions parallel to the coast by tidal currents, but predominantly northwards and landwards. Some sand is deposited where a weak rotational tidal current pattern is produced north of the inlet by the interruption of tidal currents parallel to the coast by the inlet. Waves transport the sand further onshore over the swash platform. Some of it returns to the main circulation of the inlet through the Molengat. Sand transport through the inlet is flood-dominated. It is revealed that not only the interaction of tidal currents and waves but also the interaction between the tidal currents in the North Sea and through the inlet greatly influence the system. (52 (refs)

Sharaf El Din, S. H. 1977. Effect of the Aswan High Dam on the Nile flood and on the estuarine and coastal circulation pattern along the Mediterranean Egyptian coast. *Limnology and Oceanography* 22(2):194-207.

From 60 to 180 million tons of sediments and 18×10^9 to 55×10^9 m^3 of water were transported to the Mediterranean Sea by the Nile annually before the Aswan High Dam was erected in 1964. Before completion of the dam, during the flood period the estuarine circulation pattern was a two-layer flow at the mouth of the two estuaries. In winter the circulation pattern was a one-layer flow of seawater; this pattern has persisted during most of the year since 1964. The velocity of the currents at the mouth of the Nile branches reached more than 4 knots at the surface but was less than 0.5 knot at the bottom during the flood period before 1964; after 1964 this velocity dropped considerably. General oceanographic conditions in the offshore region beyond the continental shelf did not change noticeably, but hydrographic conditions over the continental shelf in front of the delta showed considerable change after 1964. Also, since 1964 almost no sediment has been discharged from the Nile. This has produced an imbalance in the near-coast sediment budget, increasing erosion at the two mouths of the river and shifting the sediments along the coast. (24 refs)

Sheng, H., and Xiu-juan, Z. 1986. The classification and process characteristics of estuaries in China. (See complete entry in Section I.)

Sheng, Y. P. 1986. Numerical modeling of coastal and estuarine processes using boundary-fitted grids. (See complete entry in Section VI.)

Sheng, Y. P. 1986. Second-order closure modeling of turbulent flow and sediment dispersion in coastal and estuarine waters. (See complete entry in Section VI.)

Shi, L., Wei, T., and Shen, H. 1986. Diffusion and transport of seaward sediment from the Changjiang River estuary. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:602-611. University, MS: University of Mississippi.

Based on comprehensive analyses of hydrology, geomorphology, deposition, and satellite images, this paper expounds the limits and regularity of diffusion and transport of seaward sediments from the Changjiang River and roughly estimates their quantity. (10 refs)

Shideler, G. L. 1984. Suspended sediment responses in a wind-dominated estuary of the Texas Gulf Coast. *Journal of Sedimentary Petrology* 54(3):731-745.

Time-sequence measurements were made of suspended and hydrographic characteristics in Corpus Christi Bay, which is a shallow, restricted estuary typical of the Texas Gulf Coast. Quasi-synoptic measurements, obtained during eight surveys over a 2-year period, indicate that wind is the dominant forcing agent regulating estuarine sedimentary processes. Surface-sediment dispersal patterns are primarily controlled by wind direction, with

offshore-directed northerly winds producing substantially different patterns than the onshore-directed prevailing southeasterly winds. The wind direction determines the spatial intensity of bay floor sediment resuspension and the direction and efficiency of water exchange processes that control sediment dispersal within the estuarine system. Suspended sediment characteristics within the water column are primarily influenced by wind speed. Temporal trends of correlation coefficients indicate that the bay water turbidity is directly related to mean wind speed and is a short-term response parameter, being influenced mainly by cumulative wind effects within a 30-hr period prior to observation. Texturally, the suspensate consists of poorly sorted clay-size to very fine silt-size particles. Sediment grain size is inversely related to mean wind speed and is a relatively long-term response parameter, being influenced mainly by cumulative wind effects that occur 30 hr or longer prior to observation; wind speed at the time of observation has no significant influence on sediment grain size. The temporal trends of both turbidity and sediment grain size indicate that they are response parameters that reflect the water column residence time of muddy bay floor sediments episodically resuspended by wind-generated wave activity. (18 refs)

Smith, P. E., ed. 1982. *Proceedings of the conference applying research to hydraulic practice.* (See complete entry in Section I.)

Smith, T. M. 1986. Corpus Christi inner harbor shoaling investigation. (See complete entry in Section V.)

Song, W., Yoo, D., and Dyer, K. R. 1983. Sediment distribution, circulation and provenance in a macrotidal bay: Garolim Bay, Korea. *Marine Geology* 52(1/2):121-140.

A study of the sedimentary regime in Garolim Bay has been carried out in connection with a feasibility study for tidal power development. At the mouth of the bay, sand is shown to be circulating round a central bank between an ebb and a flood channel. In the middle bay, clay and heavy-mineral distributions indicate a zone where finer sediments derived from offshore mix with those originating from the local streams. Quantities of land-derived sediments are presumed to be deposited near the shores during the rainy summer season and these are redistributed during the windy winter season, but the concentrations of suspended sediment are generally low. The influx of sediment appears to largely balance the increase in sea level. Siltation over the general area may not be seriously increased after construction of a barrage, but local siltation and scour near the barrage could be serious problems. (17 refs)

Sorensen, R. M. 1990. Beach behavior and effect of coastal structures: Bradley Beach, New Jersey. *Shore & Beach* 58(1):25-29.

Bradley Beach is located on the New Jersey Atlantic shore about 15 miles south of Sandy Hook and just north of the jettied Shark River Inlet. The beach here and in adjacent shorefront communities is stabilized by stone mound groins having an average along-shore spacing of approximately a thousand feet. Net littoral transport is to the north. Bradley Breach has been defined as an area of "critical erosion" in a study done for the state of New Jersey. The author was asked by the New Jersey Department of Environmental Protection (NJDEP) to conduct a study of historic and contemporary beach conditions at Bradley Beach and adjacent coastal section, and from this, to recommend possible remedial works. The primary data sources for this study were periodic aerial photo sets dating from the early 1950's, beach profile data from as early as 1929, and contemporary beach and nearshore hydrographic data. Also, sufficient hydraulic, tidal, and hydrographic data are available for Shark River Inlet so, using the Bruun inlet stability criteria, one can estimate local net and gross longshore sediment transport rates in the study area. Primary conclusions from the study are as follows: Although the study area suffered significant shoreline recession during the 1800's and early 1900's, construction of the groin field during the 1930-1950 period has essentially stabilized the shoreline position; and the net longshore sediment transport rate in the area is much smaller (perhaps by an order of magnitude) than typically reported values. (19 refs)

Sorensen, R. M. 1989. Stability analysis of the three inlets to Venice Lagoon, Italy. (See complete entry in Section V.)

Sternberg, R. W., Caccione, D. A., Drake, D. E., and Kranck, K. 1986. Suspended sediment transport in an estuarine tidal channel within San Francisco Bay, California. *Marine Geology* 71(3/4):237-258.

A recently developed instrumentation system has been used to monitor simultaneously flow conditions and suspended sediment distribution in the bottom boundary layer of a tidal channel within San

Francisco Bay, California. Measurements were made every 15 min over six successive flood and ebb tidal cycles. They included mean velocity profiles from four electromagnetic current meters within 1 m of the seabed; mean suspended sediment concentration profiles from seven miniature nephelometers placed within 1 m of the seabed; near-bottom pressure fluctuations; vertical temperature gradient; and bottom photographs. Additionally, suspended sediment was sampled from four levels within 1 m of the seabed three times during the tidal cycle. The instrument system was retrieved during each slack-water period to exchange suspended sediment sample bags. While the instrument was deployed, STD-nephelometer measurements were made throughout the water column and water samples were collected each 1-2 hr and bottom sediment was sampled at the deployment site. Size distributions of the suspended sediment samples, estimates of particle settling velocity (w_s), friction velocity (U_*), and reference concentration (C_a) at $z = 20$ cm were used in the suspended sediment profiles. Three suspended sediment particle conditions were evaluated: (a) individual particle sizes in the 4-11 ϕ (62.5 - 0.5 μm) size range with the reference concentration C_a at $z = 20$ cm (C_ϕ); (b) individual particle sizes in the 4-6 ϕ size range, flocs representing the 7-11 ϕ size range with the reference concentration C_a at $z = 20$ cm (Cf); and (c) individual particle sizes in the 4-6 ϕ size range, flocs representing the 7-11 ϕ size range with the reference concentration predicted as a function of the bed sediment size distribution and the square of the excess shear stress. An analysis was also carried out on the sensitivity of the suspended sediment distribution equation to deviations in the primary variables w_s, U_*, and C_a. In addition, computations of mass flux were made in order to show vertical variations in mass flux for varying flow conditions. (31 refs)

Stevenson, J. C., Ward, L. G., and Kearney, M. S. 1988. Sediment transport and trapping in marsh systems: Implications of tidal flux studies. *Marine Geology* 80(1/2):37-59.

Although the concept that marshes act as major sediment sinks may be accurate when viewing them over the last few millennia, tidal transport studies suggest considerable variability with most marshes presently exporting material on an annual basis. High-salinity marshes along the mid-Atlantic coast of the United States appear to be losing 1-2 kg m^{-2} $year^{-1}$ while submerged upland marshes on the Delmarva Peninsula are eroding at rates of up to 14 kg m^{-2} $year^{-1}$. By comparison, at least one deltaic marsh on the Dutch coast along with several estuarine marshes appear to be accumulating sediment. In order to assess the trapping ability of marshes in large estuaries, a sediment budget for Chesapeake Bay was constructed which included a variety of wetland types. Calculations indicate that estuarine marshes trap 5-11 percent of the annual Chesapeake Bay sediment input, or about one half that previously estimated. It appears that most sedimentation in estuaries, and perhaps other coastal systems, occurs in subtidal flats below the limit of emergent marsh vegetation. As mud flats become vegetated and estuarine infilling proceeds, there may be a tendency for tidal currents to become ebb-dominated which promotes a net export of particulates. The extent to which major storm events are capable of returning enough material to balance the long-term accretionary budget of tidal marshes and keep them abreast of rising sea level is open to question. Differences in tidal dynamics, seasonal changes in sea levels, and higher temperatures may help explain why, in the US, southern marshes are more susceptible to export and eventual erosion than northern marshes. It is hypothesized that another factor, the recent reductions of terrigenous sediment inputs from the southern river systems of the US, may also be critical. Sediment starvation may have led to undernourishment of wetland systems of the coastal zone over the last half century which may be reflected in the net export measured in the tidal marshes in this region. Furthermore, it is postulated that changes in sediment inputs are more important than ecstatic sea level rise in causing the past losses of marshes which are now undergoing mass erosion. Thus, future wetland survival will depend as much as particulate inputs to the coastal zone as on the prospects of a global rise in sea level, and more efforts should be made to quantify the sediment budgets of tidal marshes. (127 refs)

Stride, A. H., and Chesterman, W. D. 1973. Sedimentation by nontidal currents around northern Denmark. *Marine Geology* 15(5):M53-M58.

On the shallow sea floor off northern Denmark, a number of bed forms of mobile sand can be associated with nearby sand deposits. Both appear to have been formed largely by the strong, wind-induced, intermittent coastal current, which converges from between west and south, and flows eastward past the north Danish coast. (8 refs)

Su, J., and Wang, K. 1986. The suspended sediment balance in Changjian Estuary. *Estuarine, Coastal and Shelf Science* 23(1):81-98.

Circulation and balance of suspended sediment in Changjiang Estuary have been analyzed. Strong interaction between different waterways and the fact that they are wide and shallow both contributed to the great spatial and temporal variability in circulation and suspended sediment transport. Using a flux decomposition formula with the relative depth as the vertical coordinate, it was shown that although tidal dispersion was the main dispersion mechanism in the turbidity maximum zone, dispersions due to circulation effects were also important. (7 refs)

Su, T. Y., Trujillo, J., Yue, J. P., and Wang, S. Y. 1986. Multilevel finite element simulation of sediment transport in Mobile Bay. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:323-333. University, MS: University of Mississippi.

This paper discusses the application of a multilevel finite element model of Kawahara to the simulation of hydrodynamic phenomena and sedimentation processes in the Mobile Bay of the United States. The simulation of flow field in the bay due to the influence of discharge from the Mobile River and the tidal wave from the Gulf of Mexico demonstrated that the model is both stable and without noticeable numerical damping. Sedimentation processes predicted were primarily in the close vicinity of the navigation channel. The capability of simulating vertical separation has been proven, which can improve the accuracy of prediction of sedimentation processes. (16 refs)

Swain, A., and Houston, J. R. 1985. A numerical model for beach profile development. (See complete entry in Section VI.)

†Taft, J. L. 1984. Chesapeake Bay nutrient dynamics study. Shadyside, MD: Johns Hopkins University, Chesapeake Bay Institute.

This study had two major objectives. The first was to fill gaps in the understanding of important biological, chemical, and physical processes occurring in the bay. The second objective was to collect a synoptic data set for the entire Chesapeake Bay to be used in future modeling efforts and to establish the present condition of the main bay at one point in time. The process studies were performed at various times and locations dictated by the processes themselves. Subsurface transport of nutrients and phytoplankton were examined in May 1980 in the upper bay. Sediment nutrient releases and oxygen demand were studied in eight locations in summer 1980 and spring 1981. Nitrogen and silica dynamics were examined in several locations during July, August, and September 1980. Bacterial dynamics were studied in August 1980.

†Taft, J. L., and Wang, D.-P. 1982. Vertical mixing and nutrient transport in the Chesapeake Bay. Report No. PPSP/PPRP-58. Baltimore, MD: Johns Hopkins University, Chesapeake Bay Institute.

Nutrient transport in an estuary is described. The lower Potomac River estuary is subject to variability in physical circulation and nutrient chemistry on scales of a few days. Even in the summer, when density stratification stabilizes the water column vertically, major flow events occur which can alter both nutrient concentrations, through water advection, and chemical environment, through gas and ion diffusion along newly established gradients. Soluble inorganic phosphate which is abundant in sulfide-rich deep water can be removed at the pycnocline through geochemical processes if iron and, perhaps, manganese are present. In this way it is possible for phytoplankton which can migrate down to the boundary with nutrient-rich deep water to grow at the maximal rate, while nonmigrating phytoplankton, uncoupled from the nutrient source, become phosphorus limited. Meteorological conditions in fall result in a water column which is usually stable but has much less pronounced nutrient gradients than in summer. Experiments with enclosed phytoplankton assemblages demonstrate that vertical motion through the water column, such as occurs during a wind event, enhances phytoplankton productivity in the fall and may be a positive selection factor for nonmigrating forms.

Teeter, A. M., and Hauck, L. M. 1989. An ongoing investigation of residual suspended material transport in central San Francisco Bay. (See complete entry in Section VIII.)

Teeter, A. M., and Pankow, W. 1989. Deposition and erosion testing on the composite dredged material sediment sample from New Bedford Harbor, Massachusetts. Technical Report HL-89-11. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Contaminated fine-grained sediments from upper New Bedford Harbor were tested to determine erosion, deposition, and settling characteristics. The study was performed to support an Engineering

Feasibility Study (EFS) of dredging and disposal of contaminated harbor sediments. An important issue addressed by the EFS was the possible hydraulic disposal operations. Sediment transport characteristics were required to perform mathematical modeling and make predictions. Erosion was determined for newly deposited sediments. Deposition and erosion results indicated that the sediment material was composed of three fractions. The most easily eroded sediment fraction was also the slowest to deposit, and was by far the most mobile sediment fraction. This fraction comprised 29 percent of the sediment fines, or 40 percent of the bulk sediment composite, and was composed of sediments less than 14 μm. The critical bed shear stress which initiated erosion was 0.06 N/sq m, and the critical shear stress below which deposition occurred was 0.043 N/sq m for the finest fraction. Suspended sediment settling velocities were found to increase as the four-thirds power of suspension concentration at concentrations above 75 mg/ℓ, and were found to be constant below 75 mg/ℓ at about 0.006 mm/sec. A special closed-conduit sediment water tunnel was developed to safely test contaminated sediments. The rectangular-shaped water tunnel was constructed so that a uniform cross-sectional area was maintained. Other details, including safety precautions and test limitations, are noted in the report. The results of the settling and resuspension tests conducted in the water tunnel provided data for statistical and other analysis. (10 refs)

Teisson, C., and Latteux, B. 1986. A depth-integrated bidimensional model of suspended sediment transport. (See complete entry in Section VI.)

Thomas, W. A., and McAnally, W. H., Jr. 1985. User's manual for the generalized computer program system: Open-channel flow and sedimentation, TABS-2; main text. (See complete entry in Section VI.)

Thompson, J. F., and Johnson, B. H. 1986. Generation of adaptive boundary-fitted coordinates for use in coastal and estuarine modeling. (See complete entry in Section VI.)

Tian, X. 1986. A study of the turbidity maximum in Lingdingyang Estuary, the Pearl River. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:624-633. University, MS: University of Mississippi.

Sediment siltation is relatively severe in the Lingdingyang Estuary, which is one of the estuaries of the Pearl River. This paper deals with the change and origin of turbidity maximum as well as its effect on sediment siltation in the Lingdingyang Estuary by the deduction from the net gravitational circulation, sediment deposition from flocculated suspensions, and sediment resuspension by tidal current scour. (17 refs)

†**Titley, J. G.** 1988. The microstructures of estuarine particles. Ph.D. diss., Council for National Academic Awards, United Kingdom.

A systematic study of the surface properties of suspended and bed sediments from the Tamar Estuary and Restronguet Creek was carried out using a nitrogen adsorption technique. The surface areas and porosities of the particles were determined using BET theory and capillary models applied to the gas adsorption isotherms. The surface areas of the suspended particles collected on axial transects of the Tamar Estuary ranged between 8 and 22 m^2/g. The highest values were found for particles in the turbidity maximum region. These appeared to be related in a complex way to both particle size and the chemical composition of the particles. Pores in the suspended solids (total volume 1-3 * 10^{-2} ml/g) were predominantly parallel plates in the size range 1-50 m, suggesting that clay structures were important. Pore size distributions were skewed in favor of pores <10-nm diameter, and in some cases 50 percent of the pore volume was located in micropores (<2-nm diameter). Bed sediments in the Tamar Estuary had surface areas of 6-14 m^2/g. The highest values were associated with the <45-μm and >125-μm fractions of the sediments, and a predominant relationship was observed between the Fe oxide content and surface area. Surface areas of particles from Restronguet Creek were higher (15-40 m^2/g) than from the Tamar. Distribution of surface area correlated with the smaller grain sizes and Fe content in the bed sediments. Comparison of these data with results from the Mersey Estuary (surface areas 6-14 m^2/g) showed inter- and intra-estuarine variability between the C/Fe ratio in the sediment and surface area. The microstructural information was used to refine the understanding of adsorption mechanisms involved in dissolved phosphate adsorption, including diffusion of ions into the particle matrix. This was then used to describe the mechanisms controlling the intra-estuarine variability in the transport and bio-availability of phosphate in estuaries.

†**Tommasi, L. R.** 1985. Mercury pollution in water and sediments of the bay and estuaries of Santos and Sao Vicente. (See complete entry in Section IV.)

Tran, D. N., and Merveille, J. 1986. The problem of brackish water intrusion into inland waterways--The French wateringues area. (See compete entry in Section III.)

Tsai, C.-H., and Lick, W. 1988. Resuspension of sediments from Long Island Sound (U.S.A.). (See complete entry in Section VI.)

Tunnicliffe, V., and Syvitski, J. P. M. 1983. Corals move boulders: An unusual mechanism of sediment transport. *Limnology and Oceanography* 28(3):564-568.

Tidal currents over the sill of Knight Inlet, a fjord on the western Canadian coast, are frequently in excess of 1 m sec^{-2}. This shallow sill (65 m) is composed of cobble- to boulder-sized sediments that support extensive growths of large gorgonian corals. Although current-generated shear stresses are normally far from sufficient to initiate boulder movement, drag forces due to the attached corals do cause a significant rearrangement of the boulders on the sill. (16 refs)

Ukita, M., Nakanishi, H., and Sekine, M. 1988. Study on transport and material balance of nutrients in Yamaguchi Estuary (Japan). (See complete entry in Section VI.)

Uncles, R. J., Elliot, R. C. A., and Weston, S. A. 1985. Observed fluxes of water, salt and suspended sediment in a partly mixed estuary. (See complete entry in Section VIII.)

Usseglio-Polatera, J. M., and Cunge, J. A. Modelling of pollutant and suspended sediment transport with Argos modelling system. (See complete entry in Section VI.)

van Rijn, L. C. 1986. Sedimentation of dredged channels by currents and waves. (See complete entry in Section VI.)

Vemulakonda, S. R., Swain, A., Houston, J. R., Farrar, P. D., Chou, L. W., and Ebersole, B. A. 1985. Coastal and inlet processes numerical modeling system for Oregon Inlet, North Carolina. (See complete entry in Section VI.)

Vollmers, H.-J. 1986. Physical modelling of sediment transport in coastal models. (See complete entry in Section VI.)

Vongvisessomjai, S., and Charuskumchornkul, S. 1989. Boundary conditions of tidal model at river mouth. (See complete entry in Section VI.)

Vongvisessomjai, S., and Pongpirodom, P. 1986. A laterally averaged model for estuarine sedimentation. (See complete entry in Section VI.)

†**Wagner, F., and Hart, D.** 1986. Urban estuarine systems under stress: Environmental issues facing Louisiana's Lake Pontchartrain. (See complete entry in Section IV.)

†**Walton, R., Shubinski, R. P., and Aldrich, J. A.** 1982. A three-dimensional circulation model for Chesapeake Bay. (See complete entry in Section VI.)

Wang, F. C., and Wei, J. S. 1986. River mouth mechanisms and coastal sediment depositions. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:290-299. University, MS: University of Mississippi.

The Mississippi River, the largest alluvial river system on the North American continent, has been actively building its land mass (delta lobes) for at least the past 7,000 years. The river has fed sediments through the river mouth to the receiving bay. It has built a sequence of deltaic sediments that have prograded Louisiana's coastal shoreline from the river outlet seaward to the Gulf of Mexico. The Atchafalaya River, a major tributary of the Mississippi River, flows through a relatively young alluvial basin and terminates at a shallow and well-mixed bay. The Atchafalaya River has a much steeper drop and shorter route to the sea than the Mississippi River. The diversion of fresh water and sediment from the Mississippi River to the Atchafalaya River is developing a new delta lobe on the south-central Louisiana coast. The building of this new land mass in the bay has prompted a number of widespread interests in predicting the delta evolution. This paper presents briefly the analytical approach developed and used to quantify the dynamic behavior of a river-bay-delta system. The study is focused on freshwater river discharging into a

quiescent, shallow, and well-mixed bay; the dynamic response of the bay to the forcing function; and the formation of the delta in the bay. (16 refs)

Wang, J. D., Blumberg, A. F., Butler, H. L., and Hamilton, P. 1990. Transport prediction in partially stratified water. (See complete entry in Section VI).

Wang, K., and Li, Z. 1986. Channel extension and shifting due to deposition at the modern estuary of the Yellow River. In *River Sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:634-644. University, MS: University of Mississippi.

Channel changes at the mouth of the Yellow River manifest the regularity of unceasing extension due to sediment deposition and shifting, as a result of the riverflow and sediment transport towards the sea. The process of the extension of channel due to accretion, the formation of new land, and seaward shift of the coastline, as well as the distribution of the deposits and the effect of channel extension, are being summarized; the behavior of channel shifts and their classification, the method of identification of shifting, and changing of river course and their effects were analyzed. (3 refs)

Wang, S. Y., Shen, H. W., and Ding, L. Z., ed. 1986. *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS. University, MS: University of Mississippi.

Contents: I. General lectures; II. Sediment transport in rivers; III. Estaurine and coastal sedimentation; IV. Hydraulics of sediment transport; V. Aspects of sedimentation engineering; VI. Sediment yields and sources; VII. Sedimentation processes in reservoirs and lakes; VIII. River and coastal hydrodynamics; and IX. Methodology in sedimentation research.

Wang, Y. H. 1986. Deposition behavior of fine sediments in an estaurine saline wedge. (See complete entry in Section VI.)

Wanless, H. R., Tyrrell, K. M., Tedesco, L. P., and Dravis, J. J. 1988. Tidal-flat sedimentation from Hurricane Kate, Caicos Platform, British West Indies. *Journal of Sedimentary Petrology* 58(4):724-738.

Hurricane-generated, thinly bedded grainstones are the dominant style of stratification on the carbonate tidal-flat complex on Caicos Platform, British West Indies. This is in dramatic contrast to the winter-storm-generated millimeter-thick laminae which dominate stratification on the northwest Andros tidal flats and have become the general criteria for recognizing ancient carbonate tidal-flat sequences. Hurricane Kate, which passed directly across the Caicos tidal flats on 18 November 1985, provided an opportunity both to document the character and distribution of a specific storm sediment layer and to evaluate the role of hurricanes in molding the geometry of the tidal-flat system. Though moderate in strength and producing only incomplete flooding, Hurricane Kate deposited a layer of fine to very fine peloidal grainstone 0.5-2 cm in thickness across significant portions of the extremely broad, low-relief shore and channel levees and the inland algal marsh. These storm layers are interbedded with organic-rich layers which represent prolonged periods of growth of Scytonema algal mat between hurricanes. Recognition that centimeter-thick grainstone layers dominate entire tidal-flat complexes necessitates both a thorough modification of criteria for defining ancient carbonate tidal-flat deposits and a reevaluation of supposedly subtidal, thinly bedded limestones. (20 refs)

Weber, L.-Y. L., and Leidersdorf, C. 1989. Application of hydraulic and sediment transport principles in the design of tidal exchange structures. (See complete entry in Section VI.)

Weishar, L. L., and Aubrey, D. G. 1988. Inlet hydraulics at Green Harbor, Marshfield, Massachusetts. (See complete entry in Section V.)

Weishar, L. L., and Fields, M. L. 1985. Annotated bibliography of sediment transport occurring over ebb-tidal deltas. Miscellaneous Paper CERC-85-11. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Abstracts and annotations are given for 205 published reports, dated 1984 and earlier, on the engineering and process response aspects of tidal inlet systems. This report has been compiled to update the General Investigations processes at tidal inlets. The inlet back bay regions have been viewed as interrelated systems which are dynamically dependent upon each other. Therefore, a perturbation of any part of the system will partially dictate the response of the remaining part.

†**Wellershaus, S.** 1986. Mud accumulation in estuarine channels; A question of dredging? *Environmental Technology Letters* 7(5):255-262.

For two coastal plain estuaries, the Elbe and the Weser, hydrographic data and 170-year-old and recent depth maps are used to test the hypothesis that overdeepening by dredging causes mud trapping in the estuarine channel. As a result, this hypothesis seems to give the safest interpretation for this kind of mud shoaling, although evidence is not absolute. (20 refs)

West, J. R., and Oduyemi, K. O. K. 1989. Turbulence measurements of suspended solids concentration in estuaries. (See complete entry in Section VII.)

Weydert, P., and Weydert, O. 1982. Sedimentological study of the mouth of the Gabon River Estuary (Etude sedimentologique de l'embouchure de L'Estuaire du Gabon) *Marine Geology* 49(1/2):1-22 (In French).

The 80-km-long estuary of the Gabon River is situated on the west coast of Africa, just to the north of the equator. The mouth of the estuary comprises three sectors: (a) a wide and deep navigation channel with clean sands that are very well sorted because of the strength of the tidal currents; (b) a broad shelf limited by the -10-m isobath. It extends in front of Libreville and is covered with muddy sands; tidal currents are not so strong here. Large sand banks and mud banks exist in this sector; and (c) a hard ground in the middle of the estuary with biodetrital deposits. The distribution and the facies of the deposits have been studied in relation with the tidal currents. (25 refs)

Wharfe, J. R., Dines, R. A., and Bird, L. A. 1986. The environmental impact of paper mill waste discharges to the Upper Medway Estuary, Kent, England. (See complete entry in Section IV.)

Whitelaw, K., and Andrews, M. J. 1988. The effects of sewage sludge disposal to sea--The Outer Thames Estuary, U.K. (See complete entry in Section IV.)

†**Wiberg, P. L.** 1987. Mechanics of bedload sediment transport. (See complete entry in Section VI.)

Wiley, M. L., ed. 1978. *Estuarine Interactions*; Proceedings, Fourth Biannual International Estuarine Research Conference, 2-5 October 1977, Mount Pocono, Pennsylvania. New York: Academic Press.

Contents: As blind men see the elephant: The dilemma of marine ecosystem research, by Joel W. Hedgpeth (41 refs); An environmental lawyer's uncertain quest for legal and scientific certainty, by Kenneth S. Kamlet (24 refs); Proving environmental compatibility: Sound regulatory requirement or intellectual nonsense? by James A. Rogers (13 refs); Estuarine management-user's needs, by Lloyd L. Falk (3 refs); Estuarine management panel discussion; Cumulative effects of oil drilling and production on estuarine and nearshore ecosystems, by James M. Sharp and S. G. Appan (4 refs); An evaluation of ongoing change affecting environmental geologic mapping in the Texas coastal zone, by Robert J. Finley (12 refs); Interaction between substrate, microbes, and consumers of *Spartina* detritus in estuaries, by Robert R. Christian and Richard L. Wetzel (55 refs); Box model analysis of Chesapeake Bay ammonium and nitrate fluxes, by J. L. Taft, A. J. Elliot, and W. R. Taylor (21 refs); Estuarine angiosperms: Productivity and initial photosynthate dispersion in the ecosystem, by John L. Gallagher (59 refs); An evaluation of the feasibility of a temperate climate effluent-aquaculture-tertiary treatment system in New York City, by Oswald A. Roels, Bruce A. Sharfstein, and Virginia M. Harris (15 refs); The effects of animal-sediment interactions on geochemical processes near the sediment-water interface, by Robert C. Aller (40 refs); Community unity? Patterns in molluscs and foraminifera, by Martin A. Buzas (6 refs); Spatial-temporal distributions of Long Island Sound infauna: The role of bottom disturbance in a nearshore marine habitat, by Peter L. McCall (42 refs); Seafloor stability in central Long Island Sound: Part I. Temporal changes in erodibility of fine-grained sediment, by Donald C. Rhoads, Josephine Y. Yingst, and William J. Ullman (52 refs); Seafloor stability in central Long Island Sound: Part II. Biological interactions and their potential importance for seafloor erodibility, by Josephine Y. Yingst and Donald C. Rhoads (38 refs); Predator caging experiments in soft-sediments: caution advised, by Robert W. Virnstein (17 refs); Portage, Alaska: Case history of an earthquake's impact on an estuarine system, by A. T. Ovenshine and Susan Bartsch-Winkler (10 refs); Estuarine graveyards, climatic change, and the importance of the estuarine environment, by J. R. Schubel and D. J. Hirschberg (82 refs); The impact of possible climatic changes on estuarine ecosystems, by James H. Stone, John W. Day, Jr., Leonard M. Bahr, Jr., and Robert A.

Muller (27 refs); Impact of hurricanes on sedimentation in estuaries, bays, and lagoons, by Miles O. Hayes (53 refs); Riverine influence on estuaries: A case study, by William W. Schroeder (11 refs); Influence of flooding and tides on nutrient exchange from a Texas marsh, by Neal E. Armstrong and Melvin O. Hinson, Jr. (14 refs); The effects of reduced wetlands and storage basins on the stability of a small Connecticut estuary, by Barbara L. Welsh, Janet P. Herring, and Luana M. Read (28 refs); A methodology for investigating freshwater inflow requirements for a Texas estuary, by Walter P. Lambert and E. Gus Fruh (6 refs); Polynuclear aromatic hydrocarbons in estaurine and nearshore environments, by Eugene Jackim and Carol Lake (66 refs); Relationship between bioavailability of trace metals and geochemical processes in estuaries, by Ford A. Cross and William G. Sunda (63 refs); Distribution, survival, and significance of pathogenic bacteria and viruses in estuaries, by R. R. Colwell and J. Kaper (61 refs); Sources, sinks, and cycling of arsenic in the Puget Sound region, by R. Carpenter, M. L. Peterson, and R. A. Jahnke (25 refs); Cycling of trace metal and chlorinated hydrocarbon wastes in the southern California Bight, by David K. Young, Tsu-Kai Jan, and Theadore C. Heesen (24 refs); Low-frequency response of estuarine sea level to non-local forcing, by Björn Kjerfve, J. E. Greer, and Richard L. Crout (26 refs); Physical transfer processes between Georgia tidal inlets and nearshore waters, by J. O. Blanton and L. P. Atkinson (14 refs); Distribution, composition, and morphology of suspended solids in the New York Bight Apex, by I. W. Duedall, R. Dayal, J. H. Parker, H. W. Kraner, K. W. Jones, and R. E. Shroy (29 refs); Coastal source waters and their role as a nitrogen source for primary production in an estuary in Maine, by C. Garside, G. Hull, and C. S. Yentsch (9 refs); Possible effects of Gulf Stream intrusions and coastal runoff on the benthos of the continental shelf of the Georgia Bight, by Kenneth R. Tenore, Charles F. Chamberlain, William M. Dustan, Roger B. Hanson, Barry Sherr, and John H. Tietjen (62 refs).

Williams, A. 1986. Small harbour problems in Southern China. *The Dock & Harbour Authority* 66(777):259-260.

Within the last 30 years a major problem for small harbors in Southern China has been estuarine mouth deposition. This has occurred mainly due to dam construction for the myriad of land reclamation schemes. The Wu Kan, Jiazi, and Jieshi harbors typify the problems that exist in the macro region. Proposals and the effects of various schemes on tidal flushing activities are examined in the article.

Williams, B. L. 1985. Tauranga Harbour effluent dispersion modelling study. (See complete entry in Section VI.)

Williams, D. T., Ingram, J. J., and Thomas, W. A. 1986. St. Lucie Canal and estuary sedimentation study; Mathematical model investigation. (See complete entry in Section VI.)

Wood, B. R., and Netchael, P. 1985. Hydraulic & sediment transport investigation for a coal port at Batam Island, Indonesia. (See complete entry in Section V.)

Wood, P. C., and Abel, R. 1986. Inputs into the North Sea and their effects. (See complete entry in Section IV.)

†**Yanagi, T.** 1984 Sediment transport by tidal residual flow in bays. In *Proceedings, symposium on seabed mechanics,* 5-9 September 1983, Newcastle upon Tyne, UK, ed. B. Denness, III:207-214. London: Graham and Trotman, Ltd.

This paper describes a series of detailed observations of the distribution of sediments contaminated by various pollutants, the distribution being the result of long-term residual flow, rather than tidal currents. Observations were made in the Kasado Bay area, and results for vorticity and divergence compared with tidal rise and fall are presented. A hydraulic model experiment of the Seto Inland Sea is also described, showing the effects of closure of two entrances on circulation.

Yang, C.-S. 1989. Active, moribund and buried tidal sand ridges in the East China Sea and the Southern Yellow Sea. *Marine Geology* 88(1/2):97-116.

Tidal sand ridges in the East China Sea and the Southern Yellow Sea were formed in estuarine and shallow shelf environments, where strong tidal currents reworked, transported, and redeposited large amounts of relict sands from older deltaic and fluvial sediments. The development of tidal sand ridges in estuary mouth areas is accompanied by a net sand transport from the shelf into the estuary. The evolution of tidal sand ridges is closely related to transgressions. Active tidal sand ridges are formed during sea level rises. They show distinct morphology and active migrations in a lateral as well as in a landward direction. They are generally in

equilibrium with present-day tidal processes and their distribution patterns are related to the flow field of the tidal currents. As the sea level rises further, these tidal sand ridges become moribund sand bodies with less distinct morphologies. Their upper surfaces are covered by a thin calcareous-rich layer with very high contents of foraminifera tests, reflecting a submarine hiatus condition on the shelf during the highstand period. During the subsequent steady fall in sea level, tidal sand ridges are often buried by fine-grained shelf and prodelta sediments. They have, therefore, a good chance of being preserved in stratigraphic records. The sequential buildup during a sea level rise (TR-tract) and a subsequent sea level fall (HS- and LS-tract) would consist of estuarine channel and tidal flat facies, tidal sand ridge facies, shelf mud facies, delta facies, and fluvial facies in an ascending order. Tidally dominated estuary conditions may also occur when a major distributary is abandoned, such as at the Northern Branch of the modern Changjiang River mouth, where the accumulation of sand from an abandoned delta lobe and the development of tidal sand ridges have been observed. (20 refs)

Yang, C.-S. 1986. Estimates of sand transport in the Oosterschelde tidal basin using current-velocity measurements. *Marine Geology* 72(1/2):143-170.

Estimates of sand transport have been made from middepth velocity measurements in the Oosterschelde tidal basin, southwestern Netherlands. This involves (a) the use of a two-region composite boundary-layer model in deriving the local spatially averaged bed shear stress from velocity distributions over large bed forms (megaripples and sandwaves). The two regions are divided at 100 cm above the bed, with an outer region roughness length of 1.5 cm and an inner region roughness length of 0.15 cm. (b) The application of a modified Bagnold's transport equation with the transport coefficient K depending on dimensionless excess shear stress in the form of a power law. The calculations indicate very active sand movement in the present-day Oosterschelde tidal basin. Local sediment circulation may develop around shoals. Channel floor erosion may occur in parting areas of sediment transport. The net sediment transport is mainly in the ebb direction. Estimates of sediment budget for the last 20 years show that large amounts of sand have been eroded from the Oosterschelde tidal basin and transported to the ebb-delta area. These results are comparable with other estimates from echo-sounding data, reflecting the rapid adjustment of the basin to the increased tidal prism. Such active sediment redistribution and major morphological evolution processes would have important influence on the structural organization and sequential development of estuary-ebb delta deposits. Information about the sedimentary processes in present-day estuary tidal basins is valuable for a better understanding of ancient examples. (51 refs)

Yen, K., Xue, H., and Liu, J. 1986. Coastal and estuarine sedimentation problems in China. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:257-272. University, MS: University of Mississippi.

Sediment transport, erosion, and accretion along sea coasts and in estuaries have usually caused trouble in dealing with coastal engineering works in China. Since the fifties, engineers and researchers have made efforts to investigate the coastal and estuarine sedimentation problems, and measures were taken to alleviate the harmful effects. A brief account on the characteristic features of the sea coasts and estuaries of China is given, followed by the main sedimentation problems. (12 refs)

Young, C. L., Weisman, R. N., and Lennon, G. P. 1988. Modeling deposition of suspensate in Great Sound, New Jersey. (See complete entry in Section VI.)

†**Zaitlin, B. A.** 1987. Sedimentology of the Cobequid Bay - Salmon River Estuary, Bay of Fundy, Canada. Ph.D. diss., Queen's University at Kingston, Canada.

The Cobequid Bay-Salmon River Estuary is accumulating a 25-m-thick estuarine sequence under low wave energy, low fluvial input, transgressive, macrotidal conditions. The Inner Complex (0-22 km) is funnel-shaped and fringed by marsh, mixed and mud flat deposits, whereas the Outer Complex (22-40 km) has subparallel margins and erosional foreshores. The complex as a whole is characterized by an axial sandy facies displaying a seaward change in channel and barform geometry, as follows: (a) *Zone 4,* fluvial reach above tidal influence; (b) *Zone 3,* the inner, tidally influenced single channel reach, divisible into a headward most straight reach, with ebb-asymmetric, single-terraced, bank-attacked bars (Zone 3C), a middle meandering reach with symmetrical, triple-terraced tidal point bars (Zone 3B), and an outer reach with flood-asymmetric, double-terraced, alternate bars

(Zone 3A); (c) *Zone 2*, central sand flat, characterized by a disorganized channel network bifurcating around flood-asymmetric, single-terraced "braid-bars," divisible into an inner zone dominated by UFR "sandsheet couplets" (Zone 2B), and an outer transitional braidbar elongate tidal sandbar area, with LFR megaripples and sand waves (Zone 2A); (d) *Zone 1*, flood-asymmetric, elongate tidal sandbars, separated by headward terminating flood channels and a central ebb-dominant channel; and (e) *Zone 0,* an nondepositional area seaward of the complex. Each zone is characterized by a suite of diagnostic sedimentary structures and unique vertical facies sequence. This is the manifestation of changing depositional processes through the complex. Conceptually the changes in depositional mechanism result from the transition between two opposing "energies," i.e., landward decreasing tidal head versus the seaward decreasing fluvial head. The area of crossover is in or around Zone 3B, and explains the opposing trends in grain size, tidal hydraulics, and channel and bar form geometry about Zone 3B. The area seaward of Zone 3B can be considered marine (or tidally) dominant, whereas the area landward is fluvially dominant. The concept of opposing energy gradients is fundamental to all (tidally dominant) estaurine systems. Whereas, the relative proportions of tidally versus fluvially dominant lengths in estuaries vary with the changing ratio between tidal prism, fluvial discharge, and depositional gradient, the zonation and stratigraphic sequences proposed from this complex should develop in all low wave energy, low fluvial input, tidally dominant estuarine systems.

Zarillo, G. A. 1982. Stability of bedforms in a tidal environment. (See complete entry in Section I.

Zedler, J. B., and Onuf, C. P. 1984. Biological and physical filtering in arid-region estuaries: Seasonality, extreme events, and effects of watershed modification. In *The estuary as a filter*, ed. V. S. Kennedy, 415-432. Orlando: Academic Press.

Both biological and physical processes lead to the removal of dissolved and suspended materials from water that enters estuaries. Our understanding of these "filtering functions" in southern California estuaries is summarized in three concepts: (a) In this semiarid region, ecosystems are highly seasonal in their structure and functioning, so that both the biological and physical "filters" differ for wet and dry seasons. (b) Extreme events such as floods substantially modify estuarine structure and functioning. They cause a decrease in biological functioning and dominance by physical phenomena. The effects of storm events differ for channel and marsh habitats. (c) When extreme events coincide with major human disturbances in the watershed, estuarine functioning is altered, and the changes can have long-term consequences for the ecosystem. This summary developed from comparisons of three tidally flushed systems, Tijuana Estuary, Mugu Lagoon, and Colorado Lagoon, for which data sets span years with and without major floods. The three concepts are working hypotheses that need to be tested; they should not yet be regarded as regionwide conclusions. (22 refs)

†**Zeff, M. L.** 1987. Tidal channel morphometry, flow, and sedimentation in a back-barrier salt-marsh: Avalon/Stone Harbor, New Jersey. Ph.D. diss., Rutgers-The State University of New Jersey, New Brunswick.

The tidal channels in a low-mesotidal back-barrier salt marsh of southern New Jersey consist of (a) large through-flowing (TF) channels which developed from flood tidal delta channels and connect the ocean with bays or channels to each other, and (b) smaller dead-end (DE) channels which evolved from ebb drainage patterns on the unvegetated portions of tidal delta islands and terminate on the marsh. TF channels have at-a-station hydraulic geometries similar to other tidal marsh channels, and DE channels have hydraulic geometries similar to rivers. The largest TF channel (160 m wide) had a measured mean spring v_{max} = 100 cm/sec, a mean neap v_{max} = 64 cm/sec, a spring Q_{max} = 700 m^3/sec, and neap Q_{max} = 500 m^3/sec. The smallest DE channel (1 m wide) had a mean neap v_{max} = 10 cm/sec and a neap Q_{max} < 1 m^3/sec. DE channels have low w:d ratios (5-21) with high mud perimeters (averaging 79 percent) in contrast to TF channels with higher w:d ratios (34-129) and low mud perimeters (averaging 9 percent). Three distinct environments are associated with the channels: (a) a subtidal thalweg region, (b) an intertidal channel-margin flat (vegetated and unvegetated), and (c) a channel-margin marsh (levee and back-levee). Interchannel sediment trends for each environment proceeding from large TF to small DE channels are (a) the fining of sediments from sands to silts and clays, (b) increasing total organic matter with increasing mud content, and (c) a change from predominantly physical to biological sedimentary structures. Intrachannel trends at channel cross sections are (a) the fining of sediments with distance away from the thalweg region and (b) increasing total organic matter content from the thalweg region to the

marsh. The recognition of tidal channel facies and carbon-14 dating of vibracores indicate that the seaward margins of this marsh were occupied by flood tidal deltas 1300 years BP, aggraded to intertidal flats 800-1300 years BP, and were colonized by salt marsh vegetation within the last 700 years.

Zeff, M. L. 1988. Sedimentation in a salt marsh-tidal channel system, southern New Jersey. *Marine Geology* 82(1/2): 33-48.

The tidal channels in a low-mesotidal back-barrier salt marsh of southern New Jersey are comprised of large through-flowing (TF) channels which separate marsh islands and smaller dead-end (DE) channel networks on the marsh islands. TF channels have at-a-station hydraulic geometries similar to other tidal marsh channels and DE channels have hydraulic geometries similar to rivers. The silt-clay (mud) content of DE channel perimeters is high (averaging 78 percent) and width:depth ratios are low (5-21) in contrast to TF channels with higher width:depth ratios (34-129) and lower contents of silt-clay at the perimeters (averaging 9 percent). Three distinct environments are associated with the channels: (a) a subtidal thalweg region, (b) an intertidal channel-margin flat (vegetated and unvegetated), and (c) a channel-margin marsh (levee and back levee). Inter-channel sediment trends for each environment proceeding from large TF to small DE channels are (a) a decrease in grain size of the sediments from sands to silts and clays, (b) increase in total organic matter with increasing mud content, and (c) a change from predominantly physical to biological sedimentary structures. Intrachannel trends at individual channel cross sections comprise a decrease in grain size of the sediments with distance from the thalweg region and increasing total organic matter content from the thalweg to the marsh. TF and DE channels have different origins. TF channels evolved from flood tidal delta channels that became fixed in position with the stabilization of delta shoals by vegetation and cohesive bank-margin sediments. DE channel networks, on the other hand, originated as ebb drainage patterns on the unvegetated substrates of marsh islands. They also became fixed in position by vegetation and cohesive bank margins. The two mechanisms of channel formation have resulted in little to no migration through time after this stabilization. (23 refs)

Zhou, Z., and Qiao, P. 1986. Criteria for the classification of tidal river mouths. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:1573-1582. University, MS: University of Mississippi.

On the basis of the fluvial processes in the region of the river area, different patterns of tidal river mouths are classified. Using the ratio of the channel-forming discharge of fluvial runoff to the mean tidal discharge and the sediment concentration of fluvial runoff as two indices, the different categories can be distinguished quantitatively. The critical values for different patterns of the river mouth could be used as identical ones for the distinction of the degree of mixing of fresh and salt water in tidal river mouths. (7 refs)

Zingde, M. D., Sharma, P., and Sabnis, M. M. 1985. Physicochemical investigations in Auranga River Estuary (Gujarat). (See complete entry in Section IV.)

SECTION III. SALINITY EFFECTS

Saltwater intrusion, locks separating bodies of fresh and salt water, salinity currents, saltwater barriers, and contamination by salt water as distinguished from contamination from other sources.

Aamodt, T., and Dahl, R. 1984. Modelling of tidal rivers. (See complete entry in Section VI.)

Allen, J. R. L., and Rae, J. E. 1988. Vertical salt-marsh accretion since the Roman period in the Severn Estuary, southwest Britain. (See complete entry in Section VIII.)

Anderson, G. F. 1986. Silica, diatoms and a freshwater productivity maximum in Atlantic coastal plain estuaries, Chesapeake Bay. *Estuarine, Coastal and Shelf Science* 22(2):183-197.

Monthly data collected in 1981 from the James, York, and Rappahannock rivers show that dissolved silica (= silicic acid) exhibits two distinct types of longitudinal distributions in these estuaries during the year. Conservative behavior was observed during winter or when river discharge was high. The second distribution occurs when uptake by planktonic diatoms reduces concentrations below the levels attributable to dilution by seawater. In all three systems, the nonconservation behavior is characterized by rapid uptake of silicic acid in the tidal freshwater portion, just upstream of the limit of salt intrusion, and corresponds to a chlorophyll maximum shown to contain bloom densities of diatoms. Silicic acid is exhausted below detectable concentrations in the vicinity of the diatom maximum, representing more than 98 percent removal of the riverine source. Nonconservative distributions of total silica (= silicic acid + biogenic silica) in this same region indicate deposition of biogenic silica to the sediments. At the same time the riverine source is depleted by the diatoms in the freshwater reaches, silicic acid is resupplied to the water column in the oligohaline portion of the estuaries. This resupply is shown to be significant, nearly equal to the amount of silicic acid entering the estuary in river input, suggesting complete mineralization of biogenic silica produced in the freshwater zone. The spatial distributions described above were observed regularly in all three systems, indicating that enhanced phytoplankton production and nutrient regeneration in the vicinity of the transition zone is a natural feature of these partially mixed estuarine rivers. Possible mechanisms contributing to the accumulation of phytoplankton biomass and the enhanced cycling of silicon are discussed. (49 refs)

Andrews, J. C., Dunlap, W. C., and Bellamy, N. F. 1984. Stratification in a small lagoon in the Great Barrier Reef. *Australian Journal of Marine and Freshwater Research* 35(3):273-284.

Temperatures were measured in a small lagoon in the windward reef flat of Davies Reef in the central Great Barrier Reef and examined on three time scales to gain three perspectives on thermal stratification and the trapping of bottom water. Profiling for stratification and dye revealed layering where bottom water was trapped and released by the successive capping and uncapping of the lagoon by a diurnal thermocline. A 1-month monitoring array revealed a solar synchronization, with the temperature of reef-flat water exceeding temperatures of lagoon water by up to 1.5°C within 1 hr of midday, and lagoon stratification lagging this by 1 hr. There was also a lunar synchronization with mixing proceeding during nocturnal rising tides. Lagoon surface and bottom temperatures were also monitored for 11 months. The amplitude of the diurnal stratification showed no coherence either with the amplitude of the tide (marked spring-neap tides) or with scalar wind stress. The low-frequency amplitude of the diurnal oscillation was coherent with the longshore wind vector at periods near 3.6 days and in a band approximately from 10 to 40 days. Daily stratification increased when winds were poleward and decreased when winds were equatorward. Events of flushing were separated on averaged by 9 hr, but the most frequently observed separation was 5 hr and only 10 percent of separations exceeded 18 hr during the 11 months. (16 refs)

Apelt, C. J. 1980. A decade of hydraulics in Australasia. (See complete entry in Section I.)

Ashley, G. M., and Grizzle, R. E. 1988. Interactions between hydrodynamics, benthos and sedimentation in a tide-dominated coastal lagoon. (See complete entry in Section II.)

Ashley, G. M., and Zeff, M. L. 1988. Tidal channel classification for a low-mesotidal salt marsh. (See complete entry in Section II.)

Baker, E. T. 1984. Patterns of suspended particle distribution and transport in a large fjordlike estuary. (See complete entry in Section I.)

Bales, J. D. 1989. Land drainage and estuarine salinity response. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 200-205. New York: ASCE.

An investigation is being conducted to (a) quantify the short-term effects of freshwater agricultural

drainage on salinity in a tidal creek and (b) evaluate the off-site effects of water-control structures on flow and water quality in channels that drain cropland in the Albemarle-Pamlico region of North Carolina. A continuous record of velocity is being obtained in three canals. Salinity is being recorded at two locations in the receiving water, and water-surface elevations are being measured in the canals and at two receiving-water sites. These data should provide insight into the mechanisms responsible for salinity fluctuations in the tidal creeks that receive artificial drainage. (4 refs)

Bassoullet, P., Djuwansah, R., Gouleau, D., and Marius, C. 1986. Hydrosedimentological processes and soils of the Bariot Estuary (South Kalimantan, Indonesia). (See complete entry in Section II.)

Bedford, K. W. 1985. Selection of turbulence and mixing parameterizations for estuary water quality models. (See complete entry in Section VI.)

Berger, P., Laane, R. W. P. M., Ilahude, A. G., Ewald, M., and Courtot, P. 1984. Comparative study of dissolved fluorescent matter in four West-European estuaries. (See complete entry in Section IV.)

†**Berger, T. J.** 1987. A simple numerical model for the study of baroclinic estuarine shelf interactions. (See complete entry in Section VI.)

†**Besnier, G.** 1983. Equipment of the estuary of the Vilaine; Building of Arzal Dam (L'amenagement de l'estuaire de la Vilaine; Construction du Barrage d'Arzal). (See complete entry in Section V.)

Boggs, S., Jr., and Jones, C. A. 1976. Seasonal reversal of flood-tide dominant sediment transport in a small Oregon estuary. (See complete entry in Section II.)

†**Bonnefille, R.** 1980-81. Residual phenomena in estuaries. (See complete entry in Section I.)

Bowden, K. F. 1984. Turbulence and mixing in estuaries. (See complete entry in Section I.)

Bowman, M. J., Kibblewhite, A. C., Murtagh, R. A., Chiswell, S. M., and Sanderson, B. G. 1983. Circulation and mixing in Greater Cook Strait, New Zealand. (See complete entry in Section I.)

Brockmann, C. W., and Dippner, J. W. 1987. Tidal correction of hydrographic measurements. (See complete entry in Section VI.)

Brogdon, N. J., Jr. 1986. Estuary model test evaluation. (See complete entry in Section VIII.)

Brogdon, N. J., Jr., and White, D. M. 1985. Newburyport Harbor, Massachusetts; Report 2, Design for hydrodynamics, salinity, and sedimentation; Hydraulic model investigation. (See complete entry in Section VI.)

†**Burrage, D. M.** 1986. Dynamics and short term variability of the Middle Atlantic Bight shelfbreak front. (See complete entry in Section VI.)

Butler, R. A., Covington, A. K., and Whitfield, M. 1985. The determination of pH in estuarine waters; II: Practical considerations. (See complete entry in Section VI.)

Caillat, J.-M. 1983. Effect of salinity on deposit distribution in estuarian channels. In *International conference on coastal and port engineering in developing countries,* 20-26 March 1983, Colombo, Sri Lanka, II:1207-1217. Colombo, Sri Lanka: Conventions (Colombo) Ltd.

A physical model of the Loire, France, estuary was built at the Laboratoire Central d'Hydraulique de France to study the consequences of the deepening of the access channel to the Nantes-St. Nazaire harbor. On this model, salt intrusion as well as suspended sediment movements were reproduced. The sedimentological tests were carried out with salt water at the ocean boundary and fresh water for the river discharge. Some additional tests were run with fresh water at the ocean boundary. The results of the tests were compared and show how salinity modifies the distribution of sedimentation in the estuary and the position of the turbid mass. This comparison showed that in the Loire estuary, salinity leads to a trapping of deposits in the lower estuary while the average oscillation position of the suspended mud mass is little affected by salt water. From this behavior, an attempt is made to define cases when salinity has or does not have to be reproduced on a physical scale or mathematical model when studying sedimentation in a saltwater-freshwater mixing area. (2 refs)

Casapieri, P. 1984. Environmental impact of pollution controls on the Thames Estuary, United Kingdom. (See complete entry in Section IV.)

†**Chatterjee, A. K., and Debnath, L.** 1978. Nonlinear mathematical model of inhomogeneous tidal rivers. (See complete entry in Section VI.)

†**Chatterjee, A. K., and Debnath, L.** 1980. Mathematical model for flood and embankment prediction in a tidal river. (See complete entry in Section I.)

Chen, H. S., and Unkulvasapaul, Y. 1986. Simulation of suspended/dissolved biogeochemic loads in the James Estuary, Virginia. (See compete entry in Section VI.)

Childers, D. L., and Day, J. W., Jr. 1988. A flow-through flume technique for quantifying nutrient and material fluxes in microtidal estuaries. (See complete entry in Section VIII.)

Christian, R. B., Stanley, D. W., and Daniel, D. A. 1984. Microbiological changes occurring at the freshwater-seawater interface of the Neuse River Estuary, North Carolina. In *The estuary as a filter,* ed. V. S. Kennedy, 349-365. Orlando: Academic Press.

Previously, other researchers have observed rapid biogeochemical changes at the freshwater-seawater interface (FSI) of the Tamar Estuary in England. The postulated cause of these changes is a sequence of processes triggered by mass mortality of freshwater phytoplankton. Such mortality can be viewed as an example of selective "filtration" operating at the FSI. A number of physical, chemical, and microbiological variables in the Neuse River Estuary, North Carolina, within the context of this hypothesis were examined. Nitrate nitrogen, orthophosphate, and number of phytoplankton taxa all decreased significantly ($p < 0.05$) going downriver across the FSI, while bacterial density and productivity each rose sharply ($p < 0.05$). Other parameters that were monitored (phytoplankton density, chlorophyll a, ammonia nitrogen, and light absorption coefficient) changed in the vicinity of the FSI, but none of the changes were statistically significant at the 0.05 level. In the laboratory, the effects of low salinities on the riverine microbial community were tested. Of seven variables, only bacterial density and bacterial productivity showed any significant treatment effects. Overall, the hypothesis that exposure to salt in the FSI affects the microbial community could not be confirmed. Alternate hypotheses involving nutrient availability, increased residence time of water, light availability, and population interactions are discussed. (32 refs)

Christiansen, C., Christoffersen, H., and Lomholt, S. 1981. Characteristics of three-layer circulation and inverse surface salinity gradients in two small semi-enclosed Danish embayments. *Nordic Hydrology* 12(2):119-128.

Inverse surface salinity gradients were measured in two small Danish embayments. Three possible mechanisms are taken into account. In Knebel Vig the circulation and salinity distribution can be generated by tidal modification of the stratification at the entrance which is maintained by external dynamics rather than by fresh water discharged into the embayment. In Egens Vig the involved mechanisms can be coastal upwelling and difference in heating between shallow waters near the coast and deeper waters in the central part of the embayment. (12 refs)

†**Churchill, J. H.** 1984. Analysis of flow within the coastal boundary layer off Long Island, New York. (See complete entry in Section VIII.)

Cloern, J. E. 1984. Temporal dynamics and ecological significance of salinity stratification in an estuary (South San Francisco Bay, USA). *Oceanologica Acta* 7(1):137-141.

South San Francisco Bay, United States, has periodic variations in salinity stratification that coincide with neap-spring tidal variations during the winter "wet" season, but it remains well-mixed during summer and fall. The degree of salinity stratification and timing of stratification events can be predicted from a simple empirical function of river discharge and tidal current speed. During periods of prolonged salinity stratification, phytoplankton biomass and primary productivity are high, phytoplankton patchiness increases, turbidity and nutrient concentrations decline in the surface layer, and residual currents accelerate. (31 refs)

Coenen, R. C. A. 1986. Water quality management for the Dutch sector of the North Sea. (See complete entry in Section I.)

Crickmore, M. J. 1982. Data collection -- Tides, tidal currents and suspended sediment. (See complete entry in Section VII.)

Cuff, W. R., and Tomczak, M., Jr., ed. 1983. *Synthesis and modelling of intermittent estuaries; A*

case study from planning to evaluation. (See complete entry in Section VI.)

Culkin, F., and Ridout, P. 1989. Salinity: Definitions, determinations, and standards. *Sea Technology* 10(2):47-49.

Importance of salinity distribution leads to a need for a single standard in all salinity determinations. A knowledge of salinity distribution is important in studies of circulation and mixing in both oceanic and estuarine regions, in meteorology, in acoustic measurements, and in pollution. In the past 90 years, considerable thought has been given to the concept of salinity and, as a result, its definition has undergone several changes.

Dame, R. F. 1982. The flux of floating macrodetritus in the North Inlet estuarine ecosystem. (See complete entry in Section II.)

Dankers, N., Binsbergen, M., Zegers, K., Laane, R., and van der Loeff, R. M. 1984. Transportation of water, particulate and dissolved organic and inorganic matter between a salt marsh and the Ems-Dollard Estuary, The Netherlands. (See complete entry in Section II.)

†Dean, D. M. 1987. Effluent flow study using Rhodamine dye in Theodore Barge Canal, a tidally flushed bayou in Mobile Bay, Alabama. (See complete entry in Section IV.)

de Boer, P. L., van Gelder, A., and Nio, S. D., ed. 1988. Tide-influenced sedimentary environments and facies. (See complete entry in Section II.)

Delft Hydraulics Laboratory. 1983. Mathematical modelling of estuarine phenomena. (See complete entry in Section VI.)

Delft Hydraulics Laboratory. 1986. Special issue on estuaries and coastal seas. (See complete entry in Section VI.)

de Silva Samarasinghe, J. R. 1989. Transient salt-wedges in a tidal gulf: A criterion for their formation. *Estuarine, Coastal and Shelf Science* 28(2):129-148.

The excess of evaporation over precipitation at the surface of a gulf or an embayment produces a horizontal gradient of salinity, with salinity increasing towards the head. Although there is a tendency to form salt wedges in such a situation, the water mass may be vertically well-mixed by tidal turbulence. In Gulf St. Vincent of South Australia, during its neap or "dodge" tides, which are characterized by relatively weak tidal streams, the intensity of tidally induced turbulence falls to such levels that sufficient vertical mixing cannot be sustained, allowing the formation of salt wedges only to be dissipated again by the strengthening of tidal streams towards the next spring tide. The duration of stratification can extend up to a few days depending on tidal and wind conditions. (38 refs)

Douvillé, J.-L., and Riaux, C. 1986. On the dynamics of a tidal estuary: Estimation of the principal factors (Estimation des paramètres foundamentaux de la dynamique d'un estuaire à marées). (See complete entry in Section VI.)

Dronkers, J. 1982. Conditions for gradient-type dispersive transport in one-dimensional, tidally averaged transport models. *Estaurine, Coastal and Shelf Science* 14(6):599-621.

For computations of concentration distributions in estuaries, use is frequently made of a one-dimensional, tidally averaged description of the advection-dispersion process. In this type of model, it is assumed that the dispersive mass transport is proportional to the longitudinal gradient of the cross sectionally and tidally averaged concentration. In this paper, criteria are derived for the validity of this assumption. The most important sufficient condition of validity is found to be that the number of tidal periods over which the averaging time of the one-dimensional description extends should be larger than the time scale for cross-sectional mixing. In estuaries where the longitudinal dispersion is not dominated by residual circulations in the vertical or horizontal plane, a weaker condition applies. The analysis also provides insight into the physics of the longitudinal dispersion coefficient. As an illustration of the theory field data for the salinity and velocity distribution in the Oosterschelde are examined in order to prove the gradient-type character of the dispersive salt transport. (20 refs)

†Dunbar, D. C. 1985. A numerical model of stratified circulation in a shallow-silled inlet. (See complete entry in Section VI.)

†Duursma, E. K. 1983. Aspects of residence time in estuaries. (See complete entry in Section IV.)

Dyer, K. R. 1986. *Coastal and estuarine sediment dynamics*. (See complete entry in Section II.)

Dyson, A. R., and Druery, B. M. 1985. The impact of sand extraction on salt intrusion in the Hawkesbury River. In *1985 Australasian Conference on Coastal and Ocean Engineering,* 2-6 December 1985, Christchurch, New Zealand, 1:557-567. Barton, A. C. T., Australia: The Institution of Engineers, Australia.

A study was carried out to determine the effect on tidal hydrodynamics and salt penetration of recent proposals to extract sand from the upper reaches of the Hawkesbury River. The tidal impact of possible extractive activities in Freemans Reach was modelled numerically using a one-dimensional, six-point, implicit, finite difference, hydrodynamic, network model. The results of this model were then used as input to a one-dimensional intertidal salt dispersion model, used to simulate salt concentrations in the estuary. The salinity model, based on the work of Thatcher and Harleman, Dyson, Sangmuganathan, and Sangmuganathan and Abernethy was calibrated using 12 months of continuous records of freshwater flows and salinity concentrations along the estuary. The dredging was shown to have a large effect on tidal propagation but little effect on salinity levels. (6 refs)

†**Eisma, D., Gaast, S. J. van der, Martin, J. M., and Thomas, A. J.** 1978. Suspended matter and bottom deposits of the Orinoco Delta: Turbidity, mineralogy and elementary composition. (See complete entry in Section II.)

Elbaz-Poulichet, F., Holliger, P., Huang, W. W., and Martin, J.-M. 1984. Lead cycling in estuaries, illustrated by the Gironde Estuary, France. (See complete entry in Section IV.)

†**Erasion, A., Lin, W. L., and Sharp, R. D.** 1983. FLOWER: A computer code for simulating three dimensional flow, temperature, and salinity conditions in rivers, estuaries, and coastal regions. (See complete entry in Section VI.)

†**Essaid, H. I.** 1987. Fresh water - salt water flow dynamics in coastal aquifer systems: Development and application of a multi-layered sharp interface model. (See complete entry in Section VI.)

Fagerburg, T. L. 1989. Winyah Bay, Georgetown, South Carolina, data collection survey report. (See complete entry in Section VIII.)

Farmer, D. M. 1989. Tide-induced variation of the dynamics of a salt wedge estuary. *Journal of Physical Oceanography* 19(8):1060-1072.

The time variations of the salt wedge intrusion in the Fraser Estuary, British Columbia, were monitored during a variety of tidal and runoff conditions using instruments and sampling methods that provided high resolution of the velocity and water properties in space and time. The salt wedge was found to vary considerably in position and vertical structure through the tidal cycle due to the interaction of the tidal flow with the density-driven motion of the salt wedge. During the flood, the salt wedge progressed up the estuary as a gravity current, while during the ebb the salinity structure was eroded by shear instability. The difference in character of the flow between flood and ebb is attributed to the transition between a subcritical and supercritical internal Froude number. During flood tide, the internal state is subcritical ebb flow, vertical shears become so large that the pycnocline becomes unstable, and the salt wedge structure breaks down. (23 refs)

Fields, M. L., Weishar, L. L., and Clausner, J. E. 1988. Analysis of sediment transport in the Brazos River diversion channel entrance region. (See complete entry in Section II.)

Figueres, G., Martin, J. M., Meybeck, M., and Seyler, P. 1985. A comparative study of mercury contamination in the Tagus Estuary (Portugal) and major French estuaries (Gironde, Loire, Rhone). (See complete entry in Section IV.)

Franzius, O. 1986. Suspended sediment problems in the brackish transition of the tidal Ems River. (See complete entry in Section II.)

Fryer, J. J., and Easton, A. K. 1980. Hydrodynamics of the Gippsland Lakes. (See complete entry in Section I.)

Funicelli, N. A. 1984. Assessing and managing effects of reduced freshwater inflow to two Texas estuaries. In *The estuary as a filter,* ed. V. S. Kennedy, 435-446. Orlando: Academic Press.

While a major objective of coastal zone management plans is to maintain the value and use of estuaries, decisions affecting inflow, a critical component of estuaries, are often based on considerations of water use inland. The functions of estuaries as "filters" for inland-based signals is often ignored. For effective management of both inland water resources and

estuarine freshwater inflow, methods for assessing the actual effects of inland perturbations are needed. Because no single method exists, the US Fish and Wildlife Service used a set of evaluative methods to assess the effects of reduced freshwater inflow on estuaries in Nueces-Corpus Christi and Matagorda Bays and to develop management plans for ensuring fish and wildlife productivity. The set included (a) studying the effects of environmental changes on key species, (b) regression analysis between inflow and fishery harvest data, (c) compilation and analysis of a nutrient budget, and (d) comparison of historical and projected deltaic marsh inundations. Proposed management plans to address the findings of these assessment methods involved the release of fresh water during spring and low inflow, the rerouting of selected wastewater to the river delta, and the diversion of in-channel water to inundate deltaic marshes. These plans all depend upon compromises between inland and coastal needs. (7 refs)

Furumai, H., Kawasaki, T., Futawatari, T., and Kusuda, T. 1988. Effect of salinity on nutrification in a tidal river. *Water Science and Technology* 20(6/7):165-174.

Several field surveys were conducted to investigate changes of water quality with time in the tidal River Rokkaku, where a turbidity maximum exists. Suspended solids of the turbidity maximum reach more than 20 g/l in concentration. Based on the surveys, NH_4-N, NO_2-N, and NO_3-N have peaks in concentration at certain salinities, located in order of NH_4-N, NO_2-N, and NO_3-N toward the river mouth within 10 to 25 km from it. The salinities were 0.5, 1.7, and 3.0 percent, respectively, and the maximum concentrations were about 3.0, 0.3, and 4.5 mg/l in wintertime, respectively. Laboratory batch experiments were conducted, using suspended solids and sediments taken from the river, to study the effect of salinity on nitrification and to estimate kinetics parameters of it in the river. Suspended solids and sediments were sampled at a point in the middle stream. The sediments were collected from the aerobic layer of mud, less than 1 cm thick from the surface. Experimental results indicated much more inhibition of NO_2 oxidation by salinity than that of NH_4 oxidation. Nitrifying bacteria in sediments were less sensitive to salinity than those in suspended solids. The change of nitrogen concentration with time was clearly explained with the Monod growth model and the two kinetics parameters were obtained by the curve fitting method. Maximum specific growth rates of NH_4 oxidizing bacteria ranged from 0.015 to 0.029 ($hour^{-1}$), which decreased markedly with more than 15 percent salinity. Those of NO_2 oxidizing bacteria ranged from 0.015 to 0.025 ($hour^{-1}$). Saturation constants of NH_4 and NO_2 oxidation were also dependent on salinity. Changes in NH_4-N and NO_2-N concentrations in the River Rokkaku with time were simulated well using a newly developed river model and the parameter values obtained in the laboratory tests. The mechanism of nitrification by suspended solids and sediments in the river is shown to depend on tidal effects (15 refs)

Gade, H. G., Edwards, A., and Svendsen, H., ed. 1983. *Coastal oceanography.* (See complete entry in Section I.)

Gaillard, T. R. M. G., and Huizinga, P. 1988. Hydrodynamic model study of the Kariega and Great Fish estuaries. (See complete entry in Section VI.)

†Gantt, R. G. 1988. The effect of turbidity on the infrared emissivity and thermal mapping of coastal waters. (See complete entry in Section VII.)

†Gardner, G. B. 1984. Internal hydraulics and mixing in highly stratified estuaries. Ph.D. diss., University of Washington, Seattle.

The flux of salt into the upper mixed layer plays an important role in the circulation and water quality of an estuary. An understanding of the mechanisms by which this flux occurs is of practical importance in water quality management and of scientific interest as it relates to the fluid mechanics of stratified flows. The research described in this dissertation was undertaken to test the hypothesis, suggested by the work described in Partch and Smith, that cross-pycnoclinal mixing is closely related to internal hydraulics phenomena such as the transition between subcritical (tranquil) and supercritical (shooting) hydraulic states, and associated hydraulic jumps or locally unstable shears. Measurements of the velocity and density fields were made in the Duwamish River, in Seattle, Washington. As the hydraulic processes of interest are spatially related to topography and temporally related to the tidal fluctuations in the river velocity, a new instrument deployment system was developed which allowed measurements to be made quickly from a moving research vessel. Using this system, a 3-km reach of the estuary was traversed with a round trip time of 1 hr, with nearly continuous coverage for a period of 60 hr. The hydraulic state of the estuary was investigated with the aid of a steady, hydrostatic numerical model which was adapted and extended from one described in Lee and

Su. The model indicates, for specified upstream conditions, the height of a topographic feature required to force transition from subcritical to supercritical flow, the internal or surface mode of that transition, and the resulting downstream flow field. It was found that mixing into the upper layer was limited to those times when the hydraulic state, as indicated by the model, was conducive to first internal model transitions. Additionally, the mixing occurred at identifiable topographic features, with the upper layer salinity elsewhere governed by advection. Mass and salt balance calculations provided quantitative estimates of the salt flux, and indicated that in part of the reach examined, the flux was one way, or entrainmentlike. This was not due to entrainment by a highly turbulent mixed layer, however, but to energetic processes within the pycnoline which inject fluid into the mixed layer.

Gardner, L. R., and Gorman, C. 1984. The summertime net transport of dissolved oxygen, salt and heat in a salt marsh basin, North Inlet, SC. *Estuarine, Coastal and Shelf Science* 19(3):331-339.

This study addresses the impact of marshes on the dissolved oxygen content of tidal waters, particularly during summer when respiratory demand for oxygen in adjacent coastal waters is at a maximum and the solubility of oxygen is lowest. The net transports of dissolved oxygen, salt, and heat have been measured for 65 tidal cycles during late spring and summer for a small (0.14 km^2) salt marsh basin near North Inlet, SC. The results indicate that export of dissolved oxygen occurs only on tidal cycles that begin between 2 am and 10 am such that high tide occurs within 4 hr of noon. The largest exports of oxygen and heat are produced by spring tides beginning near sunrise. Although the time window for oxygen export is only about 8 hr in duration, there is a more or less overall long-term balance between export and import because the magnitude of oxygen export is about 25 percent greater than import. The magnitude of heat export similarly exceeds heat import; but because the time windows for heat export and import are equal, there is an overall export of heat. This study thus suggests that in summer, salt marshes of the Atlantic coast export heat and are in balance with respect to the export and import of dissolved oxygen. However, because of the interaction of the diurnal tide with the daily cycle of solar radiation, transient dissolved oxygen concentrations in tidal waters can range from 1.5 to 10.0 ppm. Thus loading of additional oxygen-consuming materials to these waters possibly could lead to significant periods of anoxia. (10 refs)

Gerritsen, F. 1985. Tidal hydraulics - Historic perspective and future trends in engineering analysis. (See complete entry in Section I.)

†**Geyer, W. R.** 1985. The time-dependent dynamics of a salt wedge. (See complete entry in Section VI.)

Giese, G. L., Wilder, H. B., and Parker, G. G., Jr. 1985. Hydrology of major estuaries and sounds of North Carolina. (See complete entry in Section IV.)

†**Goodrich, D. M.** 1985. On stratification and wind-induced mixing in the Chesapeake Bay. Ph.D. diss., State University of New York at Stony Brook.

Seasonal stratification in the Chesapeake Bay is analyzed using multiyear time series of salinity and velocity from moored current meter arrays. In the midbay region, the fall-winter period is characterized by wind-induced destratification events followed by rapid restratification. In spring, a stable pycnocline is established due to increased runoff and declining intensity of spring storms. In early fall, surface cooling causes a temperature inversion which reduces the vertical density gradient by about 20 percent; destratification then occurs during strong wind events that generally occur in late September. Wind-induced mixing is neither local nor confined to surface waters. Synoptic observations from five current meter arrays in fall 1981 show well-mixed conditions extending over a distance of 130 km and to a depth of 29 m. A homogeneous water column persisted during a 1-month period for at least one of these stations. The mechanism of wind-induced destratification in the midbay region is associated with the generation of internal velocity shear. During a wind event, surface water is transported downwind; this transport sets up a sea surface slope. The slope drives bottom water upwind and causes velocity shear to be generated across the pycnocline. If this shear becomes sufficiently large, instability and large-scale mixing will occur. Following mixing, frictional coupling of surface and bottom water is increased and internal shear is reduced. Wind over a stratified water column thus generates a flow response which is depth-dependent. When the water column is well-mixed, both surface and bottom water are frictionally coupled to the wind, and response to wind is depth-independent. In the lower bay, neap-spring mixing effects are shown to be important but not dominant in determining stratification. Locally and nonlocally forced transport through the bay entrance is shown to cause large subtidal variability in salinity there. A branched, two-dimensional, laterally integrated numerical model was used to

simulate wind-induced destratification in fall 1981 and fall 1983. The formulation uses time- and space-dependent vertical eddy coefficients that are scaled to velocity shear to model internal mixing processes.

Gould, D. J., Dyer, M. F., and Tester, D. J. 1986. Environmental quality and ecology of the Great Ouse Estuary. (See complete entry in Section IV.)

Granat, M. A., Gulbrandsen, L. F., and Pankow, V. R. 1985. Reverification of the Chesapeake Bay model; Chesapeake Bay hydraulic model investigation. (See complete entry in Section I.)

Green, T. 1986. The double-diffusive aspects of sedimentation. (See complete entry in Section II.)

Grubert, J. P. 1989. Greenhouse effect on estuarine saltwater intrusion. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 188-193. New York: ASCE.

A report by the British Department of the Environment calls for research into the effect of a rise in world temperatures on sea levels. Model studies should investigate changes in the pattern of coastal erosion and deposition, as well as the effect of new coastal defenses, and the potential incursion of salt water into freshwater resources should also be evaluated. This paper addresses the latter problem as it pertains to increased saltwater intrusion into rivers due to higher sea levels and lower upland discharges, caused by the greenhouse effect. (9 refs)

Halliwell, A. R. 1986. Engineering model for well-mixed tidal basin. (See complete entry in Section VI.)

†**Hamilton, P., and Boicourt, W. C.** 1984. Long-term salinity, temperature and current measurements in Upper Chesapeake Bay. (See complete entry in Section VIII.)

Hamm, L., Barailler, L., Rambaud, B., and Hauville, S. 1986. Analysis of sediment load in the navigation channel of the Seine Estuary. (See complete entry in Section VI.)

†**Hayter, E. J.** 1983. Prediction of cohesive sediment movement in estuarial water. (See complete entry in Section VI.)

†**Hayward, D. M.** 1986. Contribution to the hydrobiology of the York River: Predicting surface mixed layer depth. Ph.D. diss., College of William and Mary, Williamsburg, VA.

Destratification in the York River, USA, during high spring tides is the result of the interruption of normal two-layer estuarine flow by advection of relatively fresh water into the river mouth from the Chesapeake Bay. This is due to the presence of a longitudinal salinity gradient in the bay and a difference of tidal current phase between the river and the bay. Similar behavior is seen in other subestuaries of the Chesapeake Bay and may be common in subestuary-estuary interactions. Correlation and regression analysis are used to examine relationships between stratification variation in the lower York River and a variety of tidal and environmental parameters. A gross measure of stratification was derived from near-surface and deep salinity samples. One hundred fifty-six observations were made over a 434-day period from February 1982 to April 1983. The environmental and tidal factors evaluated were assessed on a daily basis and incorporated a variety of transformations. The factors included wind speed and direction, freshwater riverflow from both the York and Rappahanock Rivers, water temperature, mean sea level, and the following tidal parameters: observed and predicted daily mean and maximum high and low tide height, flood, ebb, and combined flood and ebb tidal ranges for Gloucester Point and for Hampton Roads. The results indicate that (a) almost all of the tidal range or high tide height factors tested are equally strongly correlated with salinity difference, being associated with as much as 48 percent of the variation in that value; (b) a combination of functions of tidal range and mean sea level at Gloucester Point are associated with more than 70 percent of the variation; and (c) with the addition of wind stress terms as much as 80 percent of the variation can be included in the model. Over a range of observed salinity differences from 0.01 to 11.06 per mile the 25-term model predicts a range of -1.01 to 11.09 per mile with a root mean squared error of 0.99 per mile. A model predicting variation in surface mixed layer depth from salinity difference is also presented.

Hensley, J. M., and Briggs, M. J. 1988. Tidal elevations and currents at Ponce de Leon Inlet, Florida. (See complete entry in Section VIII.)

Herbertson, P. W. 1982. Salinity and resource development problems in East Kent. *Journal of the Institution of Water Engineers and Scientists* 36(6):415-436.

The promotion of a water supply reservoir in East Kent gave rise to multidisciplinary studies into the effect of the abstraction on the salinity regime of the tidal estuary downstream. The sources of salinity and their environmental effects are examined and water use in the estuary is discussed. Mathematical models have been used to predict salinity changes, and remedial measures are suggested. (6 refs)

Heywood, P. 1986. Dutch win war with the North Sea. *ENR* 216(15):28-32.

This article discusses the world's largest movable flood barrier which consists of several strings of gates totaling nearly 2 miles anchored by two artificial islands that make the entire barrier 5.6 miles long. The final design of the Oosterschelde (The Netherlands) barrier is quite different from those of its predecessors, which converted estuaries into fresh or stagnant saltwater lakes. Designers decided on a string of huge steel gates mounted between massive concrete piers. The gates will remain open except when a surge threatens. The 10-ft tidal range specified for a major shellfish farming area 20 miles from the barrier could be achieved only by building low dams across the estuary's upper reaches. They limit the area the tide has to fill and provide a nontidal shipping route between the Rhine and Schelde rivers. They also separate the salty Oosterschelde from the freshwater lakes formed by other dams to the north.

Huizinga, P. 1985. A dynamic one-dimensional water quality model. (See complete entry in Section VI.)

Huizinga, P., and Haw, P. M. 1986. A mathematical transport-dispersion model of the Knysna Estuary. (See complete entry in Section VI.)

Imberger, J., Berman, T., Christian, R. R., Sherr, E. B., Whitney, D. E., Pomeroy, L. R., Wiegert, R. G., and Wiebe, W. J. 1983. The influence of water motion on the distribution and transport of materials in a salt marsh estuary. (See complete entry in Section VI.)

Ingram, R. G. 1983. Vertical mixing at the head of the Laurentian Channel. (See complete entry in Section I.)

†**Jamshidinia, H.** 1984. Development, verification and application of a two dimensional tidal hydrodynamics model for Barataria Bay. (See complete entry in Section VI.)

†**Jay, D. A.** 1987. Residual circulation in shallow, stratified estuaries. (See complete entry in Section I.)

Johnson, B. H., Boyd, M. B., and Keulegan, G. H. 1987. A mathematical study of the impact on salinity intrusion of deepening the Lower Mississippi River navigation channel. (See complete entry in Section VI.)

Johnson, B. H., Trawle, M. J., and Kee, P. G. 1986. Discussion of a laterally averaged numerical model for computing salinity and shoaling with an application to the Savannah Estuary. (See complete entry in Section VI.)

Jones, D. G., Miller, J. M., and Roberts, P. D. 1984. The distribution of ^{137}Cs in surface intertidal sediments from the Solway Firth. (See complete entry in Section IV.)

Kennedy, V. S., ed. 1984. *The estuary as a filter.* (See complete entry in Section VI.)

Ketchum, B. H., ed. 1983. *Ecosystems of the world 26: Estuaries and enclosed seas.* (See complete entry in Section I.)

Keulegan, G. H. 1989. Estuary numbers. Technical Bulletin No. 22. Prepared for Committee on Tidal Hydraulics, US Army Corps of Engineers, by US Army Engineer Waterways Experiment Station, Vicksburg, MS.

One of the important contributions of the analysis of salinity tests conducted at the US Army Engineer Waterways Experiment Station (WES) has been the concept of the stratification number G/J where G represents the dissipation of energy in channel waters per unit mass and J the increase of potential energy of fresh water due to mixing per unit mass. Salinity distribution in the vertical and dispersion are dependent on the salinity stratification numbers. For cooscillating tides a linear theory of damped oscillations has been developed involving the friction characteristics of channel boundaries. This, however, is ignored in favor of experimental determination of a damping coefficient which is necessary to evaluate E_{sl} , which is related to G/J . This matter is fully

developed and explained. An examination of data from WES salinity tests reveals the existence of an estuary number E_{sl} , which is related to G/J . Thus E_{sl} is equally applicable like G/J to characterize salinity variations in the cross sections and diffusion. An experimental procedure for tests to verify the applicability of the ratio of the difference of the salinities in the uppermost and lowest layers and the average salinity over depth to describe salinity distribution is briefly mentioned. (8 refs)

†**Kieber, R. J., and Helz, G. R.** 1985. A first look at hydrogen peroxide in estuarine waters. In *Proceedings of the fate and effects of pollutants: A symposium,* 26-27 April 1985, College Park, MD. College Park, MD: Maryland University.

The first measurements of hydrogen peroxide in surface waters of the Chesapeake Bay and Patuxent River are presented. The peroxide content of the samples was determined using a sensitive fluorescence decay technique. The values ranged from 0.3 x 10^{-7} to 17 x 10^{-7} M. It is believed that the peroxide is produced in a natural water by a photochemical mechanism involving organic matter. The seasonal and diurnal fluctuations observed in H_2O_2 concentrations support this hypothesis. Because it can act as both an oxidant and a reductant, the peroxide will most likely be involved in environmental redox processes, some of which are suggested.

Kineke, G. C., and Sternberg, R. W. 1989. The effect of particle settling velocity on computer suspended sediment concentration profiles. (See complete entry in Section VII.)

King, C. J. H. 1980. A small cliff-bound estuarine environment: Sandyhaven Pill in South Wales. (See complete entry in Section II.)

Knanenburg, C. 1986. A time scale for long-term salt intrusion in well-mixed estuaries. *Journal of Physical Oceanography* 16(7):1329-1331.

The one-dimensional equation for dispersion of salt in a well-mixed estuary is analyzed to obtain an estimate of the departure from the quasi-steady distribution of the tidally averaged salinity in the case of a gradually varying freshwater discharge. A time scale for the adaptation of the salinity to a new situation is defined, and is found to be less than the time a fictitious particle traveling with the freshwater velocity would need to traverse the estuary. (10 refs)

Kuo, A. Y., and Neilson, B. J. 1988. A modified tidal prism model for water quality in small coastal embayments. (See complete entry in Section VI.)

Leendertse, J. J. 1984. Verification of a model of the Eastern Scheldt. (See complete entry in Section VI.)

Leendertse, J. J., Langerak, A., and de Ras, M. A. M. 1981. Two-dimensional tidal models for the Delta Works. (See complete entry in Section VI.)

Lowery, T. A., ed. 1987. *Symposium on the natural resources of the Mobile Bay Estuary.* (See complete entry in Section V.)

Lung, W.-S., and O'Connor, D. J. 1984. Two-dimensional mass transport in estuaries. (See complete entry in Section I.)

McAnally, W. H., Jr., and Stewart, J. P. 1982. Hybrid modeling of estuarine sedimentation. (See complete entry in Section VI.)

Martin, Q. W. 1987. Estimating freshwater inflow needs for Texas estuaries by mathematical programming. (See complete entry in Section VI.)

Mehta, A. J. 1987. Hydraulics and stability of a small inlet. (See complete entry in Section V.)

Mehta, A. J., Partheniades, E., Dixit, J. G., and McAnally, W. H. 1982. Properties of deposited kaolinite in a long flume. (See complete entry in Section VI.)

Moss, A. J. 1989. Water quality in residential tidal canals. (See complete entry in Section IV.)

Naik, A. S., Kanhere, V. N., and Vaidyaraman, P. P. 1983. Effect of salinity on siltation in the Cochin Port. In *International conference on coastal and port engineering in developing countries,* 20-26 March 1983, Colombo, Sri Lanka, II:1148-1162. Colombo, Sri Lanka: Conventions (Colombo) Ltd.

The importance of salinity in the estuarine environment has been recognized for quite some time in view of the sedimentation in navigable waterways being interlinked with the pattern of salinity intrusion and the resulting distribution of current velocities. Field measurements in respect to salinity, velocity, silt charge, tidal levels, etc., at various stations along the estuary, therefore, form an essential part of the

study of estuarine hydraulics. The prototype measurements carried out in tidal rivers such as the Delaware, Savannah, Charleston, Thames, etc., have helped in understanding the characteristic hydraulic behavior of these estuaries. The siltation in the Cochin Port, on the west coast of India, is typically influenced by the formation of density currents due to interaction of salt and fresh waters. Nearly 70 percent of the total siltation in the approach channel and inner channels of this port takes place during the southwest monsoon season, from June to September, when the landward transport of the sediment from the sea is accelerated due to formation of a saltwater wedge and associated density currents as a result of nonmixing of salt and fresh waters. Special simultaneous hydraulic observations were undertaken by the Central Water and Power Research Station, Pune, at seven stations in the inner channels of the port, in July 1980, for ascertaining the distribution and behavior of the saltwater wedge in the bifurcating inner channels, using sophisticated equipment received through the United Nations Development Project. This paper presents the details of the observations carried out and the findings from the analysis of the data collected.

Nassehi, V., and Williams, D. J. A. 1986. Mathematical model of Upper Milford Haven—A branching estuary. (See complete entry in Section VI.)

Nece, R. E. 1985. Physical modeling of tidal exchange in small-boat harbors. (See complete entry in Section VI.)

New, A. L., Dyer, K. R., and Lewis, R. E. 1986. Predictions of the generation and propagation of internal waves and mixing in a partially stratified estuary. (See complete entry in Section VIII.)

Nihoul, J. C. J., and Jamart, B. M., ed. 1987. *Three-dimensional models of marine and estuarine dynamics.* (See complete entry in Section VI.)

Nunes, R. A., and Simpson, J. H. 1985. Axial convergence in a well-mixed estuary. (See complete entry in Section I.)

Nuttall, P. M., Richardson, B. J., and Condina, P. 1989. Effects of saline flushing to a polluted estuary to enhance water quality standards. *Water Science and Technology* 21(2):167-176.

Kananook Creek, a polluted estuary in urban Victoria, was monitored for water quality data over a 7-year period. Prior to saline flushing, low species diversity dominated by high numbers of organic pollution-tolerant macroinvertebrates, phytoplankton blooms and cyanobacterial mats occurred throughout the estuary in clearly defined zones. Low dissolved oxygen levels restricted fish movement. Sand and silt deposition in the estuary prevented submergent aquatic plant colonization, primarily as a result of the unstable, shifting nature of the substratum. Subsequent saline flushing at a maximum continuous rate of 150 ML/day saltwater from a coastal waterway improved quality within the water column of the polluted estuary. Although flushing reduced the incidence of freshwater species, estuarine fauna and flora rapidly colonized much of Kananook Creek. The incidence of phytoplankton blooms and water discoloration and odor was reduced to the benefit of recreation demands placed upon the creek. Polluted and unstable sediments continued to restrict macroinvertebrate establishment, and occasional cessation in flushing for pump maintenance caused a rapid deterioration in water quality. (17 refs)

Odd, N. V. M., Wolfe-Barry, J. N., and Berrahim, A. 1985. Hydraulic modelling of a tidal lagoon at Benghazi. (See complete entry in Section VI.)

Oenema, O., and DeLaune, R. D. 1988. Accretion rates in salt marshes in the Eastern Scheldt, Southwest Netherlands. *Estuarine, Coastal and Shelf Science* 26(4):379-394.

Vertical accretion and sediment accumulation rates were determined from the distribution of ^{137}Cs in sediment cores, from historic documents, and from artificial white tracer layers in salt marshes in the Eastern Scheldt. Salt marsh accretion is related to the steady rise of the mean high tide in the Eastern Scheldt during the last few decades. Mean accretion rates vary from 0.4-0.9 cm year^{-1} in the St. Annaland marsh to 1.0-1.5 cm year^{-1} in the Rattekaai marsh. Sediment accumulation in accreting marshes exceeds the loss of sediment, by retreat of the marsh cliffs, by a factor of 10-20. Short-term spatial and temporal variations in accretion rates are large. Spatial variations are associated with levee and backmarsh sites and the density of marsh vegetation. Temporal variations are related mainly to fluctuations in hydrodynamic conditions. The net vertical accretion rate of organic carbon is 0.4 ± 0.1 kg m^{-2} year^{-1}; approximately half this rate is associated with the current deposit, and the other half with net additions from the belowground root biomass. A simple model for the root biomass distribution of *Spartina*

anglica with depth and the depth-dependent fossilization of root biomass in sediments of the Rattekaai marsh is presented. (41 refs)

Oey, L.-Y., Mellor, G. L., and Hires, R. I. 1985. A three-dimensional simulation of the Hudson-Raritan Estuary; Part I: Description of the model and model simulations. (See complete entry in Section VI.)

Oey, L.-Y., Mellor, G. L., and Hires, R. I. 1985. A three-dimensional simulation of the Hudson-Raritan Estuary; Part II: Comparison with observation. (See complete entry in Section VI.)

Oey, L.-Y., Mellor, G. L., and Hires, R. I. 1985. A three-dimensional simulation of the Hudson-Raritan Estuary; Part III: Salt flux analyses. *Journal of Physical Oceanography* 15(12):1711-1720.

Salt fluxes and volume transports in an estuary vary considerably over subtidal time scales of a few days to weeks in response to wind and neap-spring tidal forcings. Results from a numerical simulation of the Hudson-Raritan Estuary are used to study subtidal variations of salt fluxes and the physical mechanisms for salt balance in the estuary. Simulated salt fluxes are compared with available observations. Observations support the model's finding that analysis of volume and slat fluxes based on short-length data records (<30 days) can lead to misleading conclusions. Tidal trapping effects due to coastline irregularities contribute most to the salt balance at the Sandy Hook-Rockaway Point transect and at the Narrows. A two-week observational records is analyzed to support this finding. Simulated subtidal variation of the tidal trapping term at the Sandy Hook-Rockaway Point transect compares well with that observed. In Raritan Bay, where tidal currents are weak and effects of winds are significant, contributions to salt balance from vertical velocity and salinity gradients are comparable to transverse contributions. This occurs despite the fact that surface-to-bottom salinity differences during the simulation period- a period of low freshwater flow-never exceed 0.5% throughout most regions of the bay. A two-dimensional, depth-integrated xy-t model, in which the horizontal dispersion coefficients are modeled empirically, may not perform well in this case. (10 refs)

†**Olson, P.** 1984. Spectral model for subtidal variability in the Chesapeake Bay. (See complete entry in Section VI.)

Otvos, E. G. 1981. Barrier island formation through nearshore aggradation—stratigraphic and field evidence. (See complete entry in Section I.)

Oyegoke, E. S., Osoba, E. B., Oladapo, O. O., Uzochukwu, B. N., and Ibrahim, A. 1983. Coastal erosion problems in Nigeria and some measures adopted over the years for their solution. (See complete entry in Section V.)

Owens, N. J. P. 1986. Estuarine nitrification: A naturally occurring fluidized bed reaction? (See complete entry in Section VI.)

Parchure, T. M., and Mehta, A. J. 1985. Erosion of soft cohesive sediment deposits. (See complete entry in Section II.)

Park, J. K., and James, A. 1986. Modeling of pollutant dispersion in stratified oscillatory flows. (See complete entry in Section VI.)

Park, J. K., and James, A. 1988. Time-varying turbulent mixing in a stratified estuary and the application to a Lagrangian 2-D model. (See complete entry in Section VIII.)

†**Patel, A. V., Bhatt, N. M., Partasarathy, G. S., and Modi, P. M.** 1985. Salinity distribution, pollution dispersion and tidal flushing; A case study. *Asian Environment* 7(3):8-12.

A number of methods have been devised for computing the rate at which river water is flushed out of an estuary, and thereby estimating the rate of removal of a pollutant introduced into it. The exchange coefficients are generally determined empirically, and not analytically. Mathematical models need large quantities of reliable data from the field to arrive at initial boundary conditions. The tidal prism method and modified tidal prism method are empirical methods available to study the process of exchange in a tidal stream. The Mahi Estuary is receiving the industrial effluent discharged by the diffuser at J-point near Sarod (Jambusar). The tidal limit was observed to be at a distance of about 50 km upstream of the mouth during the summer months of May-June when the river discharge is the lowest. (3 refs)

Pejrup, M. 1986. "Parameters affecting fine-grained suspended sediment concentrations in a shallow micro-tidal estuary, Ho Bugt, Denmark. (See complete entry in Section VI.)

Pelegrí, J. L. 1988. Tidal fronts in estuaries. (See complete entry in Section I.)

Perrels, P. A. J., and Karelse, M. 1981. A two-dimensional, laterally averaged model for salt intrusion in estuaries. (See complete entry in Section VI.)

Pilarczyk, K. W., Misdorp, R., Leewis, R. J., and Wisser, J. 1986. Strategy to erosion control of Dutch estuaries. (See complete entry in Section V.)

Ports, M. A., ed. 1989. *Hydraulic engineering.* (See complete entry in Section I.)

Prandle, D. 1985. On salinity regimes and the vertical structure of residual flows in narrow tidal estuaries. *Estuarine, Coastal and Shelf Science* 20(5):615-635.

An examination is made of the circulation in narrow estuaries subject to a predominant tidal forcing. Velocity structures are derived separately for residual flow components associated with (a) river flow, (b) wind stress, (c) a well-mixed longitudinal density gradient and (d) a fully stratified saline wedge. Dimensionless parameters are introduced to indicate the magnitude of each component, and these parameters are evaluated for nine major estuaries, thereby revealing their sensitivity to each component. For a channel of constant breadth and depth, formulas are deduced for the length of saline intrusion, L. Comparisons with observed data show that such formulas may be used with confidence to predict changes in L arising from variations in river flow, tidal range, or channel depths. The level of stratification is shown to be related to a product of two parameters, one associated with velocity structure and a second involving the square of the "flow ratio" $\bar{u}/\hat{u}$ (i.e., residual velocity/amplitude of the tidal velocity). This relationship provides a simple classification system for estuarine stratification which can be used to indicate the sensitivity of any particular estuary to changing conditions. (20 refs)

Puls, W., and Kuehl, H. 1986. Field measurements of the settling velocities of estuarine flocs. (See complete entry in Section VIII.)

Radford, P. J., and West, J. 1986. Models to minimize monitoring. (See complete entry in Section VI.)

Raney, D. C., and Youngblood, J. N. 1987. Numerical modelling of salinity propagation in Mobile Bay. (See complete entry in Section VI.)

Reed, D. J. 1988. Sediment dynamics and deposition in a retreating coastal salt marsh. (See complete entry in Section II.)

Rodda, J. C., and Jones, G. N. 1983. Preliminary estimates of loads carried by rivers to estuaries and coastal waters around Great Britain derived from the harmonized monitoring scheme. (See complete entry in Section II.)

Salomão, J. M. 1987. A survey for salinity intrusion and pollution assessment in Maputo Estuary. (See complete entry in Section VII.)

Salomons, W., Schwedhelm, E., Schoer, J., and Knauth, H. 1988. Natural tracers to determine the origin of sediments and suspended matter from the Elbe Estuary. (See complete entry in Section II.)

Savenije, H. H. G. 1986. A one-dimensional model for salinity intrusion in alluvial estuaries. (See complete entry in Section VI.)

Savenije, H. H. G. 1988. Influence of rain and evaporation on salt intrusion in estuaries. *Journal of Hydraulic Engineering*, ASCE, 114(12):1509-1524.

The influence of local evaporation and rainfall on the salinity of estuary water is generally neglected in salt intrusion models. In the Gambia Estuary, it appears that the influence of rain and evaporation is important. A model is presented to simulate salt intrusion, taking into account the effects of local rain and evaporation. (5 refs)

Scale Models. 1982. (See complete entry in Section VI.)

Schaffranek, R. W., and Baltzer, R. A. 1989. Implementation of a hydrodynamic model for the upper Potomac estuary. (See complete entry in Section VI.)

Schmalz, R. A., Jr. 1985. Numerical model investigation of Mississippi Sound and adjacent areas. (See complete entry in Section VI.)

Schmalz, R. A., Jr. 1985. User guide for WIFM-SAL: A two-dimensional vertically integrated, time-varying estuarine transport model. (See complete entry in Section VI.)

Smith, L. H., and Cheng, R. T. 1987. Tidal and tidally averaged circulation characteristics of Suisun Bay, California. (See complete entry in Section VI.)

Smith, P. E., ed. 1982. *Proceedings of the conference applying research to hydraulic practice.* (See complete entry in Section I.)

†**Staples, D. J.** 1983. Environmental monitoring: Climate of Karumba and hydrology of the Norman River Estuary, southeast Gulf of Carpentaria. (See complete entry in Section VII.)

Stevenson, J. C., Ward, L. G., and Kearney, M. S. 1988. Sediment transport and trapping in marsh systems: Implications of tidal flux studies. (See complete entry in Section II.)

Storni, M. S. O., Lara, R. J., and Pucci, A. E. 1984. Tidal variations of some physico-chemical parameters in Balanca Bay, Argentina. *Estuarine, Coastal and Shelf Science* 19(4):485-491.

Oxygen, alkalinity, nutrient, pH, temperature, and salinity were measured through tidal cycles in two points of Blanca Bay. A clear dependence of nutrients, oxygen, and alkalinity with salinity and tide conditions was observed in the inner point, being attenuated in the outer one. (7 refs)

†**Swanson, J. C.** 1986. A three dimensional numerical model system of coastal circulation and water quality. (See complete entry in Section VI.)

Tee, K.-T., and Lim, T.-H. 1987. The freshwater pulse--A numerical model with application to the St. Lawrence Estuary. (See complete entry in Section VI.)

Thomas, W. A., and McAnally, W. H., Jr. 1985. User's manual for the generalized computer program system: Open-channel flow and sedimentation, TABS-2; main text. (See complete entry in Section VI.)

Thompson, G., Neville-Jones, P., and Shahabudin, S. M. 1984. Modelling estuaries for water resources studies. (See complete entry in Section VI.)

Thomson, J. D., and Godrey, J. S. 1985. Circulation dynamics in the Derwent Estuary. *Australian Journal of Marine and Freshwater Research* 36(6):765-772.

For moderate river discharges the Derwent Estuary, is strongly stratified in its upstream reaches; however, salt walter is flushed completely as far downstream as Bridgewater, for river discharges greater than about 150 m^3 sec^{-1}. Salinity returns to normal in this section within about 10-20 days of a rainstorm. The main mixing mechanism appears to be surface stirring by the wind; a semiempirical formula for wind-driven entrainment velocity gives values a factor of about 1.5 too small, but this may be due to a number of sources of observational error. Tidal mixing detectable in the upstream Derwent, but is small compared to wind mixing in terms of induced vertical flows. (15 refs)

Tidal gate capsizes salinity control job. 1987. (See complete entry in Section V.)

Tran, D. N., and Merveille, J. 1986. The problem of brackish water intrusion into inland waterways--The French wateringues area. *Bulletin of the Permanent International Association of Navigation Congresses* 53:79-95 (In French).

The protection against the penetration of saline waters into the inland waterways of the French wateringues is mainly secured by the sea locks at Gravelines and Mardyck, with excellent results. However, water quality is gradually worsened by the discharge of a fossilized salt, linked with the extension of agricultural drainage works. (2 refs)

†**Trial, W. T., Jr.** 1986. An evaluation of nitrifying activity and unionized ammonia toxicity in a salt-wedge estuary: The Duwamish River Estuary, Seattle, Washington. (See complete entry in Section IV.)

Uncles, R. J., Elliot, R. C. A., and Weston, S. A. 1985. Observed fluxes of water, salt and suspended sediment in a partly mixed estuary. (See complete entry in Section VIII.)

van Rijn, L. C. 1986. Sedimentation of dredged channels by currents and waves. (See complete entry in Section VI.)

†**Voorhis, A. D., Epifanio, C. E., Maurer, D., Dittel, A. I., and Vargas, J. A.** 1983. The estuarine character of the Gulf of Nicoya, an embayment on the Pacific Coast of Central America. (See complete entry in Section VIII.)

†**Wagner, F., and Hart, D.** 1986. Urban estuarine systems under stress: Environmental issues facing Louisiana's Lake Pontchartrain. (See complete entry in Section IV.)

Walters, R. A. 1989. Effects of runoff changes and sea level rise on salinity in the Delaware River Estuary. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 685-686. New York: ASCE.

Salinity intrusion in the Delaware River estuary due to changing climatic conditions could jeopardize existing water supplies that depend on surface withdrawals and on recharge from the freshwater part of estuary. A rise in sea level or decrease in freshwater inflows could change the salt distribution and cause saline-water intrusion to increase in the Coastal Plain aquifers. The objective of this study is to investigate changes in the spatial distribution of salt in the Delaware Estuary resulting from climate-induced changes in freshwater inflows and in the position of mean sea level. The approach adopted for this study is composed of two parts: an analysis of existing physical data in order to derive a basic understanding of the salt dynamics, and numerical simulation of future conditions based upon this analysis.

Wang, J. D., Blumberg, A. F., Butler, H. L., and Hamilton, P. 1990. Transport prediction in partially stratified water. (See complete entry in Section VI).

Wang, S. Y., Shen, H. W., and Ding, L. Z., ed. 1986. *River sedimentation.* (See complete entry in Section II.)

Wang, Y. H. 1986. Deposition behavior of fine sediments in an estuarine saline wedge. (See complete entry in Section VI.)

Weaver, A. J., and Hsieh, W. W. 1987. The influence of buoyancy flux from estuaries on continental shelf circulation. (See complete entry in Section VI.)

Weishar, L. L., and Fields, M. L. 1985. Annotated bibliography of sediment transport occurring over ebb-tidal deltas. (See complete entry in Section II.)

West, J. R. 1983. An evaluation of a moving-coordinate system model of salinity intrusion into the Mersey Estuary. *Water Pollution Control* 82(3):402-417.

The intrusion of salt water into estuaries due to tidally induced mixing processes is of importance to those concerned with engineering works which modify the fluvial discharge or the tidal water movements in estuaries. These hydraulic changes can lead to the saline contamination of freshwater abstractions, changes in patterns of shoaling, and modifications to water quality. These changes can be induced by river engineering works, such as dams and water abstractions, or by coastal engineering works such as tidal barrages and navigational channel dredging. Salinity distributions in estuaries can be predicted mathematically by solving a suitable form of the solute mass balance equation along with channel cross-section and velocity data obtained from either model predictions or field measurements. Although many solute transport models exist for estuaries, most have a number of severe limitations with respect to their ability to provide accurate predictions suitable for design decisions. All predictions, by their very nature, involve some degree of uncertainty. In salinity concentration prediction models, uncertainty arises from errors and omissions in the prototype data, numerical errors, and a lack of understanding of the physical mechanisms on which the model is based. The objectives of this paper are twofold: first, it is intended to provide some insight into the reliability of estuarine salinity concentration predictions, and second, conclusions are sought which indicate where research work should lead to improvements in the predictive capability of estuarine solute transport models. (16 refs)

West, J. R., Guymer, I., Sangodoyin, Y., and Oduyemi, K. O. K. 1986. Solute dispersion and sediment transport in estuaries. *Water Science and Technology* 18(4/5):93-100.

Synoptic measurements of velocity and salinity at several points on up to five vertical profiles at a cross section in the Conwy show that solute dispersion coefficients are affected by secondary flow induced by the interaction of transverse shear and the salinity-induced longitudinal density gradient. It is concluded that dispersion coefficients are temporally and spatially dependent and a simple empirical formula is suggested. Some data from the initial stages of a similar study of sediment transport show that techniques exist which permit the study of the turbulent fluctuations of suspended solids concentration and the evaluation of the tidal dependence of suspended solids transport phenomena. (10 refs)

West, J. R., and Mangat, J. S. 1986. The determination and prediction of longitudinal dispersion

coefficients in a narrow, shallow estuary. (See complete entry in Section VIII.)

West, J. R., and Shiono, K. 1985. A note on turbulent perturbations of salinity in a partially mixed estuary. (See complete entry in Section VIII.)

West, J. R., and Shiono, K. 1988. Vertical turbulent mixing processes on ebb tides in partially mixed estuaries. *Estuarine, Coastal and Shelf Science* 26(1):51-66.

Measurements of turbulent fluctuations of the horizontal and vertical components of velocity and of salinity in the region 1-1.25 m above the bed have been made in the Teign Estuary during parts of three ebb tides of different tidal ranges. The turbulent mean flow field determined from vertical profiles of velocity and salinity varied from well mixed to partially mixed depending on the relative importance of the vertical gradient promoting effect of shear and longitudinal density gradient and of the mixing effect of bed-generated turbulence. The turbulence parameters showed regular temporal trends. The relative intensity values for the new and existing data for the velocity components are strongly dependent on relative depth but not generally affected by Richardson number. The intensity of the salinity fluctuations increased with the salinity gradients. The vertical transport of momentum and the vertical Reynolds flux correlation coefficients decreased with Richardson number. The horizontal Reynolds flux correlation coefficient increased with Richardson number. These effects are tentatively explained by the concept of turbulent fluctuations being replaced by wavelike fluctuations in stable conditions. Results for momentum and solute mixing lengths help to substantiate previously published values. (15 refs)

†**Whiting, G. J.** 1985. Nitrogen cycling in salt marshes: Tidal and gaseous exchanges. Ph.D. diss., University of South Carolina, Columbia.

Tidal exchange of inorganic nitrogen between the North Inlet salt marsh, South Carolina, USA, and the coastal ocean indicated an export of approximately 5.0 g N m^{-2} $year^{-1}$ from the marsh to the ocean. This was based on seasonal sampling periods during the winter, spring, summer, and fall that measured the tidal exchange of the salt marsh - estuarine ecosystem that included oyster bars, mud flats, creek bottoms, water column, and vegetated marsh subsystems. Patterns in concentration of ammonia and nitrate + nitrite suggested an enrichment of the tidal water during the period of tidal ebb flow. Exchange measurements of tidal flow over the vegetated (Spartina) marsh surface over a 15-month period showed that the marsh imported 6.0 g N m^{-2} $year^{-1}$ of inorganic nitrogen. Runoff of residual tidal water during low tide exposure of the marsh surface removed 5.5 g N m^{-2} $year^{-1}$ in the form of dissolved organic and particulate nitrogen. Rain events during low tide exposure of the marsh surface accounted for events during low tide exposure of the marsh surface accounted for 25 percent of the annual estimated particulate nitrogen loss by the process of runoff. Inputs of nitrogen through nitrogen fixing bacteria in the vegetated marsh were estimated using an in situ chamber technique. On the average, nitrogen fixation brought 38.0 g N m^{2} $year^{-1}$ into the marsh. Temperature appeared to be an important factor influencing the rates of nitrogen fixation in the marsh. Exudates from plant roots seem to be supporting a large majority of the heterotrophic nitrogen-fixing bacteria in the sediment.

†**Wiberg, P. L.** 1987. Mechanics of bedload sediment transport. (See complete entry in Section VI.)

†**Wick, G. L.** 1978. Power from salinity gradients. *Energy (Oxford)* 3(1):95-100.

This energy source exists at the interface between waters of differing salinities and is particularly concentrated where freshwater rivers flows into the ocean. The power, represented by the osmotic pressure difference between fresh water and salt water, may be called salinity gradient power. Recently, this source of power has been given recognition and some modest experiments have explored means of extracting it. Two techniques, presented pressure-retarded osmosis and reverse electrodialysis, appear to be promising entrees into this energy source. Although the present cost of membranes suitable to these methods is too high, a research and development effort should make this salinity gradient energy competitive with other energy sources. (15 refs)

Wiley, M. L., ed. 1978. *Estuarine interactions.* (See complete entry in Section II.)

Wilson, J. A. 1985. The influence of an artificial hydraulic regime on water quality in the tidal river Lagan, Northern Ireland. (See complete entry in Section VI.)

Wong, K.-C. 1986. Sea-level fluctuations in a coastal lagoon. *Estuarine, Coastal and Shelf Science* 22(6):739-752.

Sea level observations made during December 1979 at six stations in Great South Bay (which is a coastal lagoon on the south shore of Long Island, New York) reveal that there were significant subtidal fluctuations in addition to the tidal oscillations. Harmonic analysis of the tidal oscillations of sea level indicates that M_2 is the dominant tidal constituent. The M_2 amplitude, however, suffered a more than 50 percent reduction in the interior of the bay due largely to the narrow inlet. The subtidal sea level fluctuations within the bay were forced primarily by the low-frequency fluctuations of the adjacent shelf water. The active subtidal exchange induced by this bay-shelf coupling appeared to have suffered only minor attenuation within the bay. As a consequence, the variance associated with subtidal sea level fluctuations was greater than that associated with the tidal oscillations over most of Great South Bay. (16 refs)

Zarillo, G. A. 1982. Stability of bedforms in a tidal environment. (See complete entry in Section I.)

Zasinska, E., and Robakiewicz, W. 1988. Hydrodynamic conditions and salinity of the Swina Strait and the Szczecin Bay. *Bulletin of the Permanent International Association of Navigation Congresses* 60:77-94.

The article describes certain characteristics of the Odra Estuary and presents the various phases and the results of research carried out in this region during the last 40 years. In a more detailed manner, it presents the conditions and results of the expeditions performed in the years 1983 and 1985. The data obtained therefrom have made it possible to determine the prevailing hydrodynamic conditions and the salinity character of waters in the Swina Strait and the Szczecin Bay. The article also gives the results of theoretical analyses performed on the basis of ground surveys. Lastly, the authors describe the unsettled character of the velocity distribution in the Swina Strait, a fact which impedes navigation. (8 refs)

Zedler, J. B., and Onuf, C. P. 1984. Biological and physical filtering in arid-region estuaries: Seasonality, extreme events, and effects of watershed modification. (See complete entry in Section II.)

†**Zhang, Q.** 1985. The interaction between estuarine plumes and continental shelf waters. (See complete entry in Section VI.)

Zhou, Z., and Qiao, P. 1986. Criteria for the classification of tidal river mouths. (See complete entry in Section II.)

SECTION IV. CONTAMINATION

Contamination from sources such as industrial wastes or sewage, as distinguished from contamination by salt water.

Al-Bakri, D. 1986. Provenance of the sediments in the Humber Estuary and the adjacent coasts, eastern England. (See complete entry in Section II.)

Allen, J. R. L. 1987. Coal dust in the Severn Estuary, southwestern UK. *Marine Pollution Bulletin* 18(4):169-174.

Substantial amounts of coal dust attributable to mining occur in the recently accumulated muddy sediments of the Severn Estuary. The pollutant is most plentiful in the finest textured deposits, and in present-day (1985) intertidal mud is found to the general order of 1×10^9 grains kg^{-1}. The coal occurs to a similar degree in muddy sediments accumulated from about 1945 to the present but declines rapidly in abundance in older deposits, a steady "background" value of about 3×10^8 grains kg^{-1} obtaining in muds antedating circa 1845. A total of at least the order of 10^5 - 10^6 tonnes of coal dust may now be present in the estuarine fine sediments. Although the Severn Estuary taps several exposed coal fields, most of the pollutant probably comes from the South Wales Coalfield, where production peaked in 1913, 30 years before the maximum of coal dust observed in the deposited sediments. (27 refs)

Amano, K., and Fukushima, T. 1988. On the longitudinal and vertical changes in lake estuarine sediments. *Water Science and Technology* 20(6/7):143-153.

In order to obtain environmental information about lake water and watersheds, the vertical and longitudinal distributions of physical and chemical properties in lake sediments were investigated. The concentrations of several substances (e.g., nutrients, metals, and chemicals) in the sediments were determined at fifty sampling sites in sixteen shallow lakes in Japan. The vertical profiles of particle size, particle organic carbon, particle organic nitrogen, total phosphorus, some metals (titanium, manganese, iron, zinc, and copper), and LAS were analyzed. Various sediment properties, such as the sedimentation conditions and the redox conditions, were related to the vertical profiles observed, and traces of historical changes in the water and watersheds were found in the sediments. Longitudinal changes in the sediments between the mouths of the rivers and the deepest points of the lakes were clearly observed, and it was expected that these changes would correlate with one of the estuarine characteristics since they reflect the spatial variation in average composition of the particulate matter and in the average water quality. Some significant relationships between the lake sediments and the lake or watershed type were observed, indicating the possibility that lake sediments may be one of the most important indices for understanding lake environments. (11 refs)

†**American Petroleum Institute.** 1986. Tidal area dispersant project: Fate and effects of chemically dispersed oil in the nearshore environment. Washington, DC: API Publications and Distribution Section, American Petroleum Institute.

This is a study, carried out in Long Cove, Searsport, Maine, by scientists at Bowdoin College, which was designed to answer the question, "would chemical dispersion of a nearshore oil spill cause more or less ecological harm than nearshore mechanical cleanup of an identical spill?" Impacts of the spills on both intertidal and subtidal sediments and their animal communities were evaluated over a 2-year period. The study results indicate that the impact of dispersed oil on the nearshore environment is significantly less than the impact of an undispersed oil spill cleaned up by conventional methods.

†**Bales, J. D.** 1986. Field and numerical studies of tracer gas transport and surface gas transfer in laterally uniform, partially stratified estuaries. (See complete entry in Section VI.)

Beasley, E. L., Hiller, M. A., and Biggs, R. B. 1988. Susceptibility of U.S. estuaries to pollution. (See complete entry in Section VIII.)

Berger, P., Laane, R. W. P. M., Ilahude, A. G., Ewald, M., and Courtot, P. Comparative study of dissolved fluorescent matter in four west-European estuaries. *Oceanologica Acta* 7(3):309-314.

Filtered waters from four European estuaries are studied directly after filtration for their fluorescence properties, using the same procedure with corrections for scattering. A high similarity in the spectral characteristics (position of emission maximum, width at midheights) is found for each estuary from upstream to downstream, and in comparison between the four estuaries. In each estuary, fluorescence intensities decrease linearly when salinity increases. These observations are correlated with the geochemical behaviour of the organic fluorescent matter in estuaries. (24 refs)

Birch, P. B., Forbes, G. G., and Schofield, N. J. 1986. Monitoring effects of catchment management practices on phosphorus loads into the eutrophic

Peel-Harvey Estuary, western Australia. *Water Science and Technology* 18(4/5):53-61.

Early results from monitoring runoff suggest that the program to reduce application of superphosphate to farmlands in surrounding catchments has been successful in reducing input of phosphorus to the eutrophic Peel-Harvey Estuary. In the estuary this phosphorus fertilizes algae which grow in abundance and accumulate and pollute once-clean beaches. The success of the program has been judged from application of an empirical statistical model, which was derived from 6 years of data from the Harvey Estuary catchment prior to a major change in fertilizer practices in 1984. The model relates concentration of phosphorous with rate of flow and time of year. High phosphorus concentrations were associated with high flow rates and with flows early in the high runoff season (May-July). The model predicted that the distribution of flows in 1984 should have resulted in a flow-weighted concentration of phosphorus near the long-term average; the observed concentration was 25 percent below the long-term average. This means that the amount of phosphorus discharged into the Harvey Estuary could have been about 25 percent less than expected from the volume of runoff which occurred. However several more years of data are required to confirm this trend. (12 refs)

Brady, J. A., Steady, R. G., and Ord, W. O. 1983. Pollution control policies for the Tees Estuary. *Water Pollution Control* 82(3):367-380.

The River Tees rises at Cross Fell in the Pennines, 893 m above sea level, and flows for some 160 km to the North Sea. The catchment area of 1,930 km^2 includes regulating and direct-supply reservoirs, and vital abstractions are made for potable and industrial consumption (260 tcmd and 230 tcmd, respectively). Tees-side has a population in excess of 400,000, is a major area of industrial development, and its port facilities, together with those at Hartlepool, handle 30 M tonnes of cargo per year. The River Tees is thus of considerable social, commercial, and industrial importance. The tidal length of the river is a notorious example of a grossly polluted estuary. For over 50 years, discharges of untreated sewage and industrial effluent have given rise to problems of deoxygenation and fish toxicity, and despite considerable reductions in polluting loads during the last 10 years, the estuary remains grossly polluted. Northumbrian Water Authority (NWA) decided to examine the costs and social benefits of alternative pollution control policies for the Tees estuary. An NWA working party was set up in 1978 to examine these issues, and the work undertaken and its outcome are the subject of this paper. (21 refs)

Cameron, I., and Ho, G. E. 1985. Disposal of wool scouring effluent in an estuarine environment. In *1985 Australasian Conference on Coastal and Ocean Engineering,* 2-6 December 1985, Christchurch, New Zealand, 1:183-192. Barton, A. C. T., Australia: The Institution of Engineers, Australia.

A wool scouring plant discharges its waste effluent into the Swan River estuary in Western Australia via a submerged outfall on an ebbing tidal flow. A feature of the outfall is that it discharges countercurrent to the ebbing flow. The objective of the work reported in this paper was to investigate the dispersion of the effluent by laboratory simulation and field study. The laboratory simulation was achieved by applying the concepts of dynamic similarity and secondary scaling ratios to provide relationships between prototype and model. The trajectory and dilution characteristics of the simulated buoyant jet were determined by microdensitometer scanning and computer-assisted analysis of photographic negatives, complemented with the placement of a light probe in the plume. These methods, which are believed to be novel for this particular application, were developed to assess whether waste effluent dilution by countercurrent discharge was superior to that of the conventional concurrent method of discharge on an ebbing tidal flow within an estuarine environment. The agreement between the results of the various methods was good, and indicated that there was little difference between countercurrent and concurrent discharge. (13 refs)

Cantillo, A. Y., Calder, J. A., Long, E. R., and Peter, G. 1984. A new emphasis on coastal and estuarine environment quality assessment. In *Oceans '84 conference record: Industry, government, education...Designs for the future,* 10-12 September 1984, Washington, DC, 1:302-308. Piscataway, NJ: The Institute of Electrical and Electronics Engineers, Inc.

The National Oceanic and Atmospheric Administration has initiated a new program called the Status and Trends (S&T) Program, within which a series of activities will be undertaken to quantify the current status and long-term, temporal, and spatial trends of key contaminant concentrations, water quality parameters, and biological indications of adverse effects in the Nation's coastal and estuarine environments. Key questions the S&T program intends to answer are (a) what are the current conditions of the

Nation's coastal zone and (b) are these conditions getting better or worse? The S&T Program has four major components: benthic surveillance, "mussel watch," water quality, and compilation of a data base from relevant existing programs.

Casapieri, P. 1984. Environmental impact of pollution controls on the Thames estuary, United Kingdom. In *The estuary as a filter,* ed. V. S. Kennedy, 489-504. Orlando: Academic Press.

A brief introduction is given to the historical background relating to the early history of pollution of the Thames Estuary. Particular emphasis is placed on the reasons for deterioration and its subsequent dramatic improvement. Legislative measures that were necessary to enable improvements to be made are described. The process of development of water quality objectives and quality standards associated with them in the United Kingdom from the late 1950's to the present day is discussed. The Thames is finally recovering from a hundred years of serious pollution. Over one hundred species of fish are present in the estuary, some in very large numbers, and the river has been shown capable of supporting a salmonid fish population. (11 refs)

†**Chevereau, C., and De Sogreah, M.** 1977. Mathematical models applied to the study of morphological processes and pollutant propagation in coastal regions. (See complete entry in Section VI.)

Coenen, R. C. A. 1986. Water quality management for the Dutch sector of the North Sea. (See complete entry in Section I.)

Cuff, W. R., and Tomczak, M., Jr., ed. 1983. *Synthesis and modelling of intermittent estuaries; A case study from planning to evaluation.* (See complete entry in Section VI.)

Curtis, R. J. 1985. Tidal recirculation of dredge spoil: Major sedimentary process in Lyttelton Harbour, South Island, New Zealand. (See complete entry in Section II.)

Cutter, G. A. 1989. The estuarine behaviour of selenium in San Francisco Bay. *Estuarine, Coastal and Shelf Science* 28(1):13-34.

In April and September 1986, concentrations of dissolved selenate, selenite, and Se(-II+0), suspended particulate selenium, nutrients, chlorophyll *a* and total suspended matter were determined in the San Francisco Bay estuarine system. In addition, dissolved selenium speciation was determined in the Sacramento and San Joaquin rivers between 1984 and 1987. The April 1986 estuarine sampling occurred during high river discharge, and within the Northern Reach of San Francisco Bay mid-estuarine input of selenite and Se(-II+0) is apparent, while selenate appears to be removed. During September 1986 river discharge rates were approximately four orders of magnitude lower than in April, and the mid-estuarine production of all selenium species is apparent. In contrast, dissolved selenium in the South San Francisco Bay generally shows conservative mixing behaviour during April and September 1986. The source of dissolved selenium in the South Bay appears to be effluent from sewage treatment plants. In the Northern Reach, effluent from oil refineries located in the mid-estuary may be major sources of selenium input during low river discharge periods. However, during periods of high river discharge, the sources and sinks of dissolved selenium species within the Northern Reach remain unidentified. (27 refs)

†**Daiber, F. C.** 1986. Conservation of tidal marshes. (See complete entry in Section V.)

Das, K. C. 1987. The upper James Estuary--A study in water quality management. *Water Science and Technology* 19(9):1-7.

The James River has its headwaters in the Allegheny Mountains and flows generally southeasterly to Hampton Roads, Chesapeake Bay, and thence to the Atlantic Ocean. Below Richmond, Virginia, the river is tidal with the channel meandering through the coastal plains. Below Hopewell it widens to a broad estuary, with a deep navigable channel bordered by tide marshes. The upper estuary, between Richmond and Hopewell, is heavily used for water supply, recreation, and industrial development. The water entering the estuary a few miles upstream of Richmond is of good quality. However, as one reaches Richmond, the quality of the water deteriorates. There are eleven major discharging municipalities and industries within a stretch of twenty-two river miles between Richmond and Hopewell. The major factors contributing to water quality problems below the city of Richmond stem from the intermittent discharge from combined sewer overflows (CSO's) coupled with the continuous discharge from the city's sewage treatment plant. The CSO's contribute a large quantity of soluble biochemical oxygen demand (BOD), suspended solids, settleable solids, and fecal coliform to the estuary. The city's sewage treatment plant

continuously discharges large quantities of ammonia-nitrogen and phosphorus, in addition to BOD and suspended solids. Rational management and use of the waters of the upper James estuary appear to be critical. The objectives of this paper, therefore, are the discussion of the present water quality and the wastewater discharge reductions required in order to meet certain water quality and water use objectives. (10 refs)

†**Dean, D. M.** 1987. Effluent flow study using Rhodamine dye in Theodore Barge Canal, a tidally flushed bayou in Mobile Bay, Alabama. In *Symposium on the natural resources of the Mobile Bay Estuary,* February 1987, Mobile, Alabama, ed. Tony A. Lowery, 175-186. Mobile, AL: Alabama Sea Grant Extension Service, Alabama Cooperative Extension Service, Auburn University.

Theodore Barge Canal and Ship Channel are modifications of Deer River; the system is a tidally flushed bayou and is similar to the relatively unmodified adjacent bayous, Fowl River and Dog River. Flushing studies of an industrial effluent, tagged with Rhodamine WT dye, were run in Theodore Barge Canal in November 1986 to assess the potential effect of wastewater from proposed industrial expansion in the area. Twenty-seven stations were sampled for 30 days. The major flow of effluent, 53 percent in one day, is attributed to the movement of the low-density effluent on the surface. The low-density effluent, which was tagged, had a residence time (99 percent flowed out of the canal) of only 15 days. A "Cell Model," derived from the sampled data, is used to predict the dye concentrations values at equilibrium. The model predicts that effluent will not become concentrated in the canal. Data from the study suggests that Mobile Bay and Theodore Ship Channel act as a salt-wedge estuary. Seawater moves in along the bottom of the system and surface water flows out.

D'Elia, C. F. 1987. Nutrient enrichment of the Chesapeake Bay: Too much of a good thing. *Environment* 29(2):6-11, 30-33.

The Chesapeake Bay, one of the most productive estuaries in the United States, is also a sink for much of the waste generated in the regions flanking the bay. The runoff contributes nutrients that encourage the proliferation of phytoplankton, which are in large part responsible for the decline of the bay. Scientific evidence is zeroing in on the precise mechanisms by which these microscopic organisms proliferate, and how to best check their growth. (5 refs)

Dejak, C., Lalatta, I. M., Messina, E., and Pecenik, G. 1987. Steady-state achievement by introduction of true tidal velocities in a pollution model of the Venice Lagoon. (See complete entry in Section VI.)

Dejak, C., Lalatta, I. M., Messina, E., and Pecenik, G. 1987. Tidal three-dimensional diffusion in a model of the Lagoon of Venice and reliability conditions for its numerical integration. (See complete entry in Section VI.)

Delft Hydraulics Laboratory. 1983. Mathematical modelling of estuarine phenomena. (See complete entry in Section VI.)

Delft Hydraulics Laboratory. 1986. Special issue on estuaries and coastal seas. (See complete entry in Section VI.)

Dixon, A. 1985. The Mersey Estuary pollution alleviation scheme. *Journal of the Institution of Water Engineers and Scientists* 39(5):401-413.

The Mersey Estuary receives the surface drainage, sewage, and trade waste flows from the catchments of the rivers Mersey and Weaver. The drainage area of 4,535 km^2 includes the highly urbanized and industrialized areas of Merseyside, Greater Manchester, South Lancashire, and North Cheshire with a total population of over 5 million people of whom about one-quarter live along the banks of the estuary. The estuary is some 50 km in length from the tidal limit at Howley Weir, in Warrington, to the defined seaward boundary which is a line drawn between points in New Brighton and Crosby. For the whole of this length the quality of the estuarial water is classified as Class C and Class D, i.e., poor and bad. This is the result of the discharges of crude sewage, strong trade effluent, partially treated sewage, and polluting freshwater inputs. All of these contributing elements have been present for many years and together produce a problem which is of long standing. A general plan is shown of the estuary indicating the major centers of population and the locations of the various sewage treatment sites mentioned in the paper. Companion papers presented to this Institution in 1977 reported on the approach of the North West Water Authority to this problem and outlined the progress towards a solution which had been made at that time. Water quality objectives for the estuary were stated as: (a) The estuary should at all times contain dissolved oxygen in order to obviate odor nuisance. (b) The foreshore and beaches should not be subject to fouling by crude sewage or solids or fats from industrial effluent.

These objectives have remained the basis for the planning of remedial measures. The first objective being particularly relevant to the upper estuary and the second to the lower estuary, which is defined as downstream of a line drawn from Hale to Ellesmere Port. It was also indicated at that time that the achievement of these objectives could only result from a step by step improvement of the Authority's own discharges matched by those of industry. Again, this philosophy has not changed. At the time of reporting in 1977, sewage treatment sites for the lower estuary had not been identified for either the Liverpool bank or the Wirral bank, and the screening of individual outfalls was still being considered. Sewage treatment sites in the upper estuary did exist, all of which were capable of development to produce higher quality effluent. The quality effluent required at each site was undecided.

†**Duursma, E. K.** 1983. Aspects of residence time in estuaries. *Journal of Research Oceanography* 8(4):105-113.

The Dutch delta region is discussed as an example of the residence time of pollutants in estuaries.

Elbaz-Poulichet, F., Holliger, P., Huang, W. W., and Martin, J.-M. 1984. Lead cycling in estuaries, illustrated by the Gironde Estuary, France. *Nature* 308:409-413.

The cycling of lead in estuaries involves a complex exchange between dissolved and particulate phases. In macrotidal estuaries such as the Gironde (France), dissolved lead is adsorbed onto particles due to an increase in turbidity and in the specific surface area of particles in the tidal estuary. In the lower estuary a mobilization of exchangeable and carbonate lead occurs simultaneously with a coagulation of organic dissolved lead associated with iron-manganese hydrous oxides. The lead-depleted particles are subsequently recycled to the tidal estuary by landward currents, where they become mixed with fresh riverborne particles. Lead isotopic ratios and particulate lead speciation studies indicated that in this estuary the mixing of polluted particles with old deposits probably has a minor role in the decrease in particulate lead. (7 refs)

Ellis, D. 1989. The Thames Estuary: A managed ecosystem. *Marine Pollution Bulletin* 20(4):151-152.

Thames Estuary is now an environmentally managed ecosystem with the general objectives of maintaining fish populations, while receiving potentially polluting aquatic wastes from Greater London's sewage and river catchments. The approach to management by Thames Water is significant in principle which is essentially to develop and operate a system so that the estuary can effectively manage itself. The anchor to the management system is a string of seven continuously sensing and telemetering dissolved oxygen probes spanning about 50 km along the narrowest and worst-case section of tidewater downstream from Teddington weir, the head of the estuary. The telemetered signals are collated by computer and can be read out together at the appropriate Thames Water office.

Falconer, R. A. 1984. A mathematical model study of the flushing characteristics of a shallow tidal bay. (See complete entry in Section VI.)

Falconer, R. A. 1986. Water quality simulation study of a natural harbor. (See complete entry in Section VI.)

†**The fate and effects of pollutants: A symposium.** 1985. Proceedings of the Symposium, 26-27 April 1985. College Park, MD: Maryland University.

To answer questions about the transport and behavior of waterborne pollutants—especially in estuaries such as the Chesapeake Bay—scientists from the University of Maryland and elsewhere convened for a symposium on "The Fate and Effects of Pollutants." The symposium, held on 26 and 27 April 1985, was sponsored by the University of Maryland's Sea Grant College and Marine-Estuarine-Environmental Sciences Program. This proceedings, a compilation of the invited papers, is a record of that effort.

Fiddes, D., and Lack, T. J. 1989. Management of recreational water quality in estuaries and coastal waters--An integrated strategy. *Water Science and Technology* 21(2):83-92.

Major programs are being undertaken in UK coastal areas to reduce the environmental impact of sewage discharges to estuarial and coastal waters. A particular requirement is compliance with the European Communities Bathing Water Directive: experience has shown that cost-effective environmentally acceptable schemes can be designed incorporating long sea outfalls but only if all major sources of pollutant loading are considered concurrently and sewer, river, and marine modelling techniques and standards harmonized. To develop this integrated approach, the UK Water Industry has mounted a major research

program. The resulting procedure is described and the concept of use areas and associated quality standards introduced. The need for regular performance monitoring of outfalls is stressed and appropriate equipment described. (4 refs)

Figueres, G., Martin, J. M., Meybeck, M., and Seyler, P. 1985. A comparative study of mercury contamination in the Tagus Estuary (Portugal) and major French estuaries (Gironde, Loire, Rhone). *Estuarine, Coastal and Shelf Science* 20(2):183-203.

Concentrations of mercury were determined for the waters, suspended matter, and sediments of the Tagus and of major French estuaries. The Tagus Estuary is one of the most contaminated by mercury derived from the outfalls of a chloralkali plant and from other industrial sources. In deposited sediments, the median level, 1.0 μg Hg g^{-1}, is twenty times higher than the natural background and Hg contents depend on the sediment grain size, age, and the distance from waste outfalls. Suspended matter is more regularly and highly contaminated (median value: 4.5 μg Hg g^{-1}). In the French estuaries, Hg levels in the suspended material decrease with salinity due to dilution and/or remobilization processes. In June 1982, in the Loire estuary, high values of Hg were observed in the middle estuary and attributed to urban and industrial sources. In the Tagus Estuary, the general distribution of total dissolved Hg confirms the contamination: it increases seaward from 10 ng^{-1} in the river to 80 ng l^{-1} in the estuary outlet. The dissolved Hg is almost totally organic in the river, inorganic in the middle estuary due to inorganic Hg effluent, and again organic in the lower estuary. This variation is related to the dissolved organic carbon values. The dissolved Hg levels in the Loire Estuary (5-300 ng l^{-1}) are much higher than in the Gironde Estuary (3-6 ng l^{-1}) and of the same order as those observed in the Tagus Estuary. (34 refs)

Friligos, N. 1985. Nutrient conditions in the Euboikos Gulf (West Aegean). *Marine Pollution Bulletin* 16(11):435-439.

The Euboikos Gulf is a restricted embayment on the eastern coast of Greece, having a significant, unusual tidal phenomenon, and receiving some industrial and domestic wastes. The South Euboikos Gulf has only slightly greater concentrations of nutrients than background, while the North Euboikos Gulf tends to accumulate nutrients, in particular nitrate and silicate. Also a comparison is made with the nutrient concentrations in polluted coastal gulfs of the Aegean. The different nutrient levels are due to the different sources of nutrients, as well as the morphology of each area and the circulation of the waters. (13 refs)

Furumai, H., Kawasaki, T., Futawatari, T., and Kusuda, T. 1988. Effect of salinity on nitrification in a tidal river. (See complete entry in Section III.)

Gerritsen, F. 1985. Tidal hydraulics - Historic perspective and future trends in engineering analysis. (See complete entry in Section I.)

Giese, G. L., Wilder, H. B., and Parker, G. G., Jr. 1985. Hydrology of major estuaries and sounds of North Carolina. US Geological Survey Paper 2221. Alexandria, VA: US Geological Survey.

Hydrology-related problems associated with North Carolina's major estuaries and sounds include contamination of some estuaries with municipal and industrial wastes and drainage from adjacent, intensively farmed areas, and nuisance-level algal blooms. In addition, there is excessive shoaling in some navigation channels, saltwater intrusion into usually fresh estuarine reaches, too-high or too-low salinities in nursery areas for various estuarine species, and flood damage due to hurricanes. (79 refs)

Glegg, G. A., Titley, J. G., Millward, G. E., Glasson, D. R., and Morris, A. W. 1988. Sorption behaviour of waste-generated trace metals in estuarine waters. (See complete entry in Section II.)

Gould, D. J., Dyer, M. F., and Tester, D. J. 1986. Environmental quality and ecology of the Great Ouse Estuary. *Water Pollution Control* 86(1):84-103.

This paper describes an ecological study initiated and funded by the Anglian Water Authority in order to fulfil its statutory obligations in respect to estuaries and coastal waters. In particular the study aimed to obtain information to permit an objective assessment of the biological status of the estuary in response to allegations of the general demise of the local fisheries and possible links with pollution of the estuary. It was also necessary to obtain information in relation to a proposal to reduce the residual flow from the Ely Ouse at Denver. The study was carried out over the period 1982 to 1985 on a collaborative basis by the Anglian WA, Hull University, and Water Research Centre (WRC) at a cost of about £250,000. (11 refs)

†Hires, R. I., Oey, L.-Y., and Mellor, G. L. 1983. Prediction of oil spill trajectories in New York Harbor. *Civil Engineering for Practicing and Design Engineers* 2(6):585-625.

Trajectories of surface oil slicks for various spill scenarios in New York Harbor were obtained as part of a preliminary feasibility study of the establishment of a crude oil receiving facility. The surface current distribution required for the trajectory predictions was found from a synthesis of two-dimensional numerical model predictions of vertically averaged tidal currents and field observations. The predicted trajectories were highly sensitive to the time of release of the oil relative to the phase of the tidal current cycle at the spill site. For all but one scenario, the oil spills were found to move through the harbor and finally into the ocean in time intervals ranging from 3 to 8 days. For one release site in the Arthur Kill for a particular tidal phase, the predicted oil movement after 20 days failed to clean the harbor. (9 refs)

Hockin, D. C., and Parker, D. M. 1988. The effects of development of a tidal barrage upon the water and sediment quality of the Mersey Estuary (U.K.) and its biota. *Water Science and Technology* 20(6/7):229-233.

The prime constraint upon the development of a tidal power generating barrage is the use of the Mersey Estuary as a waste disposal facility. Historical disposal of persistent wastes continues to cause environmental problems, even though modern practices have resulted in a reduced pollution load. Mercury and lead have the greatest environmental significance, although with reference to barrage operation the nutrient status and increased transmission of light through less turbid water will be of equal or greater importance. A constraint upon the recreational use of the impounded water body will be the unacceptable numbers of fecal bacteria. A criterion for the design of the barrage should be the maximization of the volume of water entering on each tidal cycle to disperse nutrients and pollutants and import as much oxygen as possible. This will minimize the increase of retention time and reduce the probability of methylation of mercury within the sediment. Additionally it will have implications for the feeding behavior of the internationally important wildfowl populations. (8 refs)

Hodgkin, E. P., and Birch, P. B. 1986. No simple solutions: Proposing radical management options for an eutrophic estuary. *Marine Pollution Bulletin* 17(9):399-404.

A large, poorly flushed, lagoonal estuary in south-western Australia has become seriously eutrophic as the result of the input and retention of phosphorus from agricultural fertilizer applied to infertile, well-drained, sandy soils. The accumulation of masses of rotting macroalgae on the shores causes a major nuisance, and annual blooms of the blue-green alga *Nodularia* produce a nauseating smell, anoxic conditions in the shallow water, and faunal deaths. Improved agronomic measures have resulted in some reduction in phosphorus input, but input and recycling from the sediment store are still sufficient to maintain the eutrophic condition. Reversal of this situation necessitates major changes to agricultural practices in the catchment and probably construction of a second channel to the sea. While construction of the second channel would increase the loss of phosphorus from the estuary, it would also change the character of the estuarine environment, more particularly by making it more marine than now; however, it would ensure the future health of an estuary that is made naturally vulnerable to increasing human pressure by its restricted connection with the sea and the seasonal extremes of rainfall and riverflow. (7 refs)

Holly, F. M., Jr., and Usseglio-Poletera, J.-M. 1984. Dispersion simulation in two-dimensional tidal flow. *Journal of Hydraulic Engineering,* ASCE, 110(7):905-926.

An accurate numerical method for the mathematical modeling of contaminant dispersion in two-dimensional tidal currents is developed and applied. The method avoids the excessive numerical damping or oscillations associated with most finite difference and finite element schemes for advection by using a characteristics approach with high-order Hermite bicubic interpolation. The split-operator algorithm, incorporating a Crank-Nicolson operator for diffusion, provides a relatively simple and economic method for accurate simulation of pollutant dispersion on a fixed Eulerian mesh. A special procedure for Lagrangian calculation of the dispersion of concentration fields which are small compared to the mesh size simulates the early stages of growth of point source plumes. These various procedures are described in detail, and their performance is demonstrated by application to schematic test cases and to the Bay of Saint-Brieuc, France. (24 refs)

Horie, T. 1988. The role of modelling in the control of seawater pollution. (See complete entry in Section VI.)

Huizinga, P. 1985. A dynamic one-dimensional water quality model. (See complete entry in Section VI.)

Isphording, W. C. 1987. Mobile Bay: The right estuary in the wrong place. In *Symposium on the natural resources of the Mobile Bay Estuary.* February 1987, Mobile, Alabama, ed. Tony A. Lowery, 165-174. Mobile, AL: Alabama Sea Grant Extension Service, Alabama Cooperative Extension Service, Auburn University.

No estuary in the northern Gulf of Mexico has been the subject of greater controversy during the past 5 years than Mobile Bay. The discovery of a major gas field beneath the bay, its selection as a home port site for the new Gulf flotilla, a request for docking privileges for a toxic waste incinerator ship near the head of the bay, and a request for construction of new outfall lines and sediment disposal sites within the bay have all generated lively discussion. When compared with other bays in the northern Gulf, however, Mobile Bay is found to be less able to cope with potential environmental incidents than the other estuaries because of its already environmentally stressed nature and the fact that its basic characteristics have conspired to assure that it receives maximum impact from any environmental accident. A high smectite clay and organic carbon content, combined with the extremely fine textured nature of its sediments, increase the probability that both organic and inorganic pollutants will enjoy long-term residency should an accident occur. Some indication is now also present to indicate that spillover of heavy metals to the resident biota has already taken place. (22 refs)

Johnson, B. H., Boyd, M. B., and Keulegan, G. H. 1987. A mathematical study of the impact on salinity intrusion of deepening the Lower Mississippi River navigation channel. (See complete entry in Section VI.)

Jones, D. G., Miller, J. M., and Roberts, P. D. 1984. The distribution of ^{137}Cs in surface intertidal sediments from the Solway Firth. *Marine Pollution Bulletin* 15(5):187-194.

The distribution of ^{137}Cs from the Sellafield (Windscale) nuclear fuel reprocessing plant has been examined in detail in the surface intertidal sediments of the inner Solway Firth using a hovercraft-borne radiometric survey. With the exception of a belt of relatively active sands to the south of Silloth, cesium distribution is generally consistent with that of fine-grained sediment such that the highest concentrations occur in mud flat and salt marsh sediments which are most extensive in sheltered coastal embayments. ^{137}Cs activities in July 1980 were typically 2-30 pCi g^{-1} but locally exceeded 50 pCi g^{-1}. These levels are considerably lower than those recorded in locations, such as the outer Solway and Ravenglass estuary, which are closer to the Sellafield outfall. (30 refs)

Jones, E. R., and Hubbard, S. D. 1986. Maryland's phosphate ban--History and early results. (See complete entry in Section V.)

†**Josanto, V., and Sarma, R. V.** 1985. Coastal circulation off Bombay in relation to waste water disposal. *Mahasagar* 18(2):334-345.

Flow patterns in the coastal waters of Bombay, India, were studied using recording current meters, direct reading current meters, floats, and dye in relation to the proposed waste water disposal project of the Municipal Corporation of Greater Bombay from 1976 to 1978. The water movements were mainly tide-induced and elliptical in nature, with the major axis more or less parallel to the coast. The currents were mainly towards the northeast at a bearing of approximately at 30 deg during flood and towards the southwest approximately at 210 deg during ebbs. A strong onshore component was noticed in the nearshore waters mainly due to the wind drift; and it is quite likely that a portion of the effluent material released 3 km offshore, could, under extreme wind-induced drift, reach the shore in about 6 to 10 hours.

Kilset, K., and Heiberg, A. 1988. Evaluation of the "Fugacity" (FEQUM) and the "EXAMS" chemical fate and transport models: A case study on the pollution of the Norrsundet Bay (Sweden). (See complete entry in Section VI.)

Kawara, O. 1988. Study on the seasonal variation of surface sediment composition in estuaries. (See complete entry in Section II.)

Kennedy, V. S., ed. 1984. *The estuary as a filter.* (See complete entry in Section VI.)

Ketchum, B. H., ed. 1983. *Ecosystems of the world 26: Estuaries and enclosed seas.* (See complete entry in Section I.)

†**Kieber, R. J., and Helz, G. R.** 1985. A first look at hydrogen peroxide in estuarine waters. (See complete entry in Section III.)

Kuiper, J., de Wilde, P., and Wolff, W. 1984. Effects of an oil spill in outdoor model tidal flat ecosystems. (See complete entry in Section VI.)

Lask, E. 1988. Rescue of Venice finally under way. (See complete entry in Section V.)

Levenson, H. 1987. Estuaries and coastal waters need help. *Environmental Science & Technology* 21(11):1052-1054.

This article discusses how the marine environments--estuaries, coastal waters, and the open ocean--have been used extensively by coastal communities and industries for the disposal of various wastes. The projection of continued or increasing degradation is of great concern because estuaries and coastal waters are among the most important of all marine environments with respect to their commercial resources, recreational uses, and ecological roles. The author suggests that a workable strategy, not new legislation, is necessary to protect these waters. (2 refs)

Lloyd, P. J., and Cockburn, A. G. 1983. Pollution management and the tidal Thames. *Water Pollution Control* 82(3):392-401.

This paper sets out to show a method of pollution management which allows for the interaction of several discharges. In most freshwater rivers there is only limited straightforward interaction between discharges, and most of these are made by the water authority which also manages the river. However, in tidal waters where there is an ebb and flow, there is a much more complex interaction between discharges as the to and fro movement of the water can cause discharges to have effects both upstream and downstream of the point of entry to the estuary. Further, in estuaries there are often many significant discharges which are not made by the water authority. This is particularly so in the Thames Estuary, and there has already been an attempt to produce a basis for a management policy for the tidal Thames which takes account of the interaction of discharges. This started as described by Wood and Cockburn, culminating in the work of Cockburn, Griggs, and Lloyd. However, Cockburn, et al., made it clear that the method proposed had inherent difficulties, and so the method of pollution management described here evolved and has been adopted as the Thames Water Authority policy for water quality management in the tideway. (11 refs)

Lowery, T. A., ed. 1987. *Symposium on the natural resources of the Mobile Bay Estuary.* (See complete entry in Section V.)

Lung, W.-S. 1986. Assessing phosphorus control in the James River Basin. (See complete entry in Section VI.)

Lung, W.-S. 1988. The role of estuarine modeling in nutrient control. (See complete entry in Section VI.)

McLaren, P., and Little, D. I. 1987. The effects of sediment transport on contaminant dispersal: An example from Milford Haven. *Marine Pollution Bulletin* 18(11):586-594.

Milford Haven is an estuary that has been subjected to industrial pollution from tanker operations and refinery and power station effluent since about 1962. Consequently buildup of various anthropogenic heavy metals and hydrocarbons has been observed in the bottom sediments. This paper describes (a) a new technique whereby the patterns of net sediment transport are determined from the relative changes of grain size distributions in 125 grab samples, and (b) how net sediment transport correlates with the quantity of contaminants contained in the bottom sediments. The analysis demonstrates that sediment movement in the flood direction dominates the central channel and the northern half of the estuary. Transport in the ebb direction is confined to the southern coastal zone. A comparison of the transport paths with contaminant concentrations shows clearly that the flood-dominant movement leads to concentration of heavy metals and hydrocarbons. As a result, an area of fine-grained deposition near the head of the estuary receives exceptionally high concentrations of contaminants. The ebb-dominant transport, on the other hand, causes dilution in the amount of pollutants contained in the sediments. The derived transport paths agree well with known current patterns, and this technique is shown to be a rapid and inexpensive method for (a) environmental impact assessment, (b) establishing effective monitoring programs, (c) predicting areas vulnerable to contamination, and (d) rational contingency planning. (11 refs)

†**Mills, D. J. L.** 1988. The impact of hydrocarbon pollution on meiobenthic production within an estuarine mud-flat. Ph.d. diss., Heriot-Watt University, United Kingdom.

This dissertation describes the effect on the production ecology of the meiofauna resulting from the discharge of effluent by British Petroleum subsidiaries onto the mud-flats at Kinneil in the Firth of Forth. The effluents contain hydrocarbons, and other organic and inorganic chemicals, and exert a high BOD and COD leading on the surrounding mud-flats. Three stations were selected for routine meiofaunal sampling, at approximately the same tidal level, between MTL and MHWS. Routine sampling for meiofauna was conducted on fourteen occasions from April 1984 to April 1985, using 5.5 cm^2 sawn-off syringes. Nematode body masses were estimated using species-specific predictive regression equations relating maximum body width to volume. Laboratory culture of the dominant meiobenthic copepoda was conducted in order to identify the naupliar stages. The gross morphology of the nauplii of *Stenhelia palustris, Amphiascoides limicola, Platychelipus littoralis, Nannopus palustris, Mesochra lilljeborgi and Microarthridion fallax* is described. The Belehradek function $D = a.(T - a)^b$ relating development times D (nauplius to nauplius) to temperature T, was fitted to available growth data for *M. lilljeborgi* ($D = 1320.(T - 2)^{-1.05}$), and *A. limicola* ($D = 334.(T - 3)^{-0.575}$). A simple development model assuming constant proportional increase in mass at each moult except for egg/N1 and N6/C1, has been developed. A marked seasonality was observed in the abundance of virtually all species at all stations. Despite the seasonality, Detrended Correspondence analysis (ordination) reveals that the principal source of variation in the species composition is explained by the spatial axis. The ordination identified *Diplolaimella ocellata* and *Monhystera disjuncta* as characteristic of station A. *D. ocellata* attained very high dominace at this station in late summer. *Tripyloides spp., Hypodontolaimus balticus, Daptonema spp., Mesochra lilljeborgi, Platychelipus littoralis* attained their maximum abundance at station B; and *Ptycholaimellus ponticus, Sabatieria pulchra, Atrochromadora microlaima, Sphaerolaimus spp., Stenhelia palustris and Amphiascoides limicola* at station C. The method of Zelinka is redescribed, and the assumptions and limitations of the method discussed. Production figures were derived using this technique for the dominant species of harpacticoids at each station.

Milne, R. A., Nicholas, P. C., Pattinson, C., and Halcrow, W. 1986. The definition of effluent discharge consent conditions in complex estuarine environments. *Water Science and Technology* 18(4/5):267-276.

The Welsh Water Authority puts considerable emphasis upon the scientific determination of discharge consents through which it controls coastal pollution. It also pursues a policy which encourages the effective use of estuarine and coastal capacity to assimilate effluent. Conflict between environmental protection and cost-effective effluent disposal is minimized by concentrating upon the relationships between environmental quality objective (E.Q.Q.), environmental quality standard (E.Q.S.), and discharge consent. Welsh Water has devoted considerable resources to the understanding and prediction of these relationships in estuaries and has developed a protocol for consent setting. This protocol is described and illustrated with examples from recent work on the Loughor and Dee estuaries in Wales. Desk study, specialized investigations, and mathematical modelling techniques are integrated to identify critical processes in the dispersal, degradation, and biological impact of pollutants. These are modelled to predict effluent behavior for various discharge regimes, allowing a flexible approach to the selection of a consent. (16 refs)

†**Mirsajadi, H. D.** 1988. Development of a water quality-based mixing zone in estuaries. Ph.D. diss., George Washington University, Washington, DC.

When a pollutant is discharged into a body of water, it disperses in all directions. This dispersion and mixing reduces the concentration of the pollutant around the point of discharge. Because of this phenomenon, regulatory agencies responsible for management and protection of waters have assigned an area around the point of discharge within which water quality standards may not apply. This area is called a mixing zone. Because the existing regulations are not specific with regard to the size of mixing zones, this study was initiated in order to develop a simple method for estimating the size of pollutant-specific mixing zones in estuaries. In this study, after a literature review of the physical, chemical, and biological phenomenon which may effect the size of mixing zones, a mathematical model (IBM-PC Version TOXIWASP Model) was selected and was applied to an estuarine system (Bush River, Maryland). After performing an exhaustive sensitivity analysis on the model, the average value of two coefficients, namely, Transverse Mixing Zone Coefficient (TMZC) and Longitudinal Mixing Zone Coefficient (LMZC), were determined. These coefficients which in fact are the normalized longitudinal and transverse distances from the edge of mixing zone to the outfall were then used in order to estimate the Maximum Allocated Transverse Mixing

Zone (MATMZ) and Maximum Allocated Longitudinal Mixing Zone (MALMX) for pollutants with known acute to chronic toxicity ratios. Similar procedures were recommended for cases where the acute and chronic toxicity of the pollutant are not known. The developed method is considered to be applicable for estimating the size of mixing zones in shallow estuaries where a single source of pollutant is discharged continuously into the mid channel. Future studies are required in order to expand the use of the method for other cases such as a shore-attached discharge, an impulse or periodic discharge, simultaneous discharge of multiple pollutants, etc.

†**Mogolesko, F. J.** 1978. Development of an analytical technique for the design of a submerged thermal discharging system in a tidal estuary. Ph.D. diss., New York University, New York City.

The discharge waste heat from electric power plants into coastal waters has the potential for adversely affecting the aquatic ecology of receiving waters. In this study, a semi-infinite, shallow receiving body of water is identified as the sink for waste heat from a nuclear power plant. From a review of the open literature, a multiport diffuser is identified as the preferred discharge system for the dispersal of heated discharge effluent. The analysis of the near-field surface temperature rise induced by the multiport diffuser under variable tidal conditions is the primary objective of this study.

Moss, A. J. 1989. Water quality in residential tidal canals. *Water Science and Technology* 21(2):53-58.

Monitoring of water quality in residential tidal canals in Queensland has been carried out since 1974. Some recent data from four separate canal systems and their source waters are presented. Source water quality was generally good, and this high quality was maintained in surface waters throughout these systems. Stratification of the water column in poorly flushed canal branches led to periodic deterioration in bottom water quality, but this never resulted in significant management problems. Based on the Queensland data and on data from other Australian and overseas canal systems, conclusions are drawn about significant factors affecting canal water quality. These include flushing rates, source quality, polluting inputs, freshwater inflows, and depth. Finally, possible objectives for canal water quality are discussed. (12 refs)

Nuttall, P. M., Richardson, B. J., and Condina, P. 1989. Effects of saline flushing to a polluted estuary to enhance water quality standards. (See complete entry in Section III.)

Oey, L.-Y., Mellor, G. L., and Hires, R. I. 1985. A three-dimensional simulation of the Hudson-Raritan Estuary; Part I: Description of the model and model simulations. (See complete entry in Section VI.)

Officer, C. B. 1981. Tidal exchanges and far field effects. *Journal Water Pollution Control Federation* 53(10):1551-1552.

This is a brief article which discusses the far field effects, i.e., the wastes returned to the discharge area. Specifically, the discussion is limited to semi-enclosed bays connected to the ultimate coastal or ocean receiving waters for which the exchanges between the bay and coastal waters are dominated by tidal exchanges. (4 refs)

Onishi, Y., and Thompson, F. L. 1986. Sediment and contaminant transport in a marine environment. (See complete entry in Section VI.)

Páez-Osuna, F., Botello, A. V., and Villanueva, S. 1986. Heavy metals in Coatzacoalcos Estuary and Ostion Lagoon, Mexico. *Marine Pollution Bulletin* 17(11):516-519.

The Coatzacoalcos Estuary is a tropical estuarine system located on the southern Gulf of Mexico, having the typical pollution problems of an urban and oil industry estuary coupled with the fact that the estuary is small. All the refuse coming from the industries is discharged directly or indirectly into the river estuary. The refuse contains a very large variety of chemical residues, especially hydrocarbons and heavy metals. Additionally the shipping channels are dredged temporarily introducing large amounts of sediment into the water column. Ostion Lagoon is a shallow water body and is apparently free of human influence. It is classified as a differential erosion type which was formed by nonmarine processes during lowered sea level. (20 refs)

Park, J. K., and James, A. 1986. Modeling of pollutant dispersion in stratified oscillatory flows. (See complete entry in Section VI.)

Park, J. K., and James, A. 1988. Time-varying turbulent mixing in a stratified estuary and the application to a Lagrangian 2-D Model. (See complete entry in Section VIII.)

†Patel, A. V., Bhatt, N. M., Partasarathy, G. S., and Modi, P. M. 1985. Salinity distribution, pollution dispersion and tidal flushing; A case study. (See complete entry in Section III.)

Pommeruy, M., Cormier, M., Brunel, L., and Breton, M. 1987. Bacterial flora studied in a Brittany Estuary (Elorn, rade de Brest, France) (Étude de la flore bactérienne d'un estuaire breton (Élorn, rade de Brest, France)). *Oceanologica Acta* 10(2):187-196 (In French).

The purpose of this study is to evaluate the behavior of the bacterial flora of a macrotidal estuary, originating from different sources: the Elorn freshwater river, a sewage treatment plant (STP), and the sediment. Viable counts were done using several culture media in order to determine where bacteria originated. Principal component analysis showed that the estuary was subjected to two well-defined conditions. On the one hand, during periods of low turbulence (neap tide), resuspension of bottom sediments did not occur. Bacterial flora decreased from the upper reaches of the estuary to its lower part, coming mainly from two sources (river and STP). As a function of salinity variations, bacterial flora showed a progressive increase of the endogenous flora percentage versus contaminating flora (Enterobacteria). On the other hand, during periods of high turbulence (spring tide, high riverflow), a third source of contamination as sediment resuspension was combined with the previous processes. (30 refs)

Ports, M. A., ed. 1989. *Hydraulic engineering*. (See complete entry in Section I.)

Radford, P. J., and West, J. 1986. Models to minimize monitoring. (See complete entry in Section VI.)

Readman, J. W., Preston, M. R., and Mantoura, R. F. C. 1986. An integrated technique to quantify sewage, oil and PAH pollution in estuarine and coastal environments. *Marine Pollution Bulletin* 17(7):298-308.

An analytical protocol is described which allows parallel quantification of sewage, oil and PAH pollution on the same sample, thus maximizing the information gained for the effort expended. Capillary gas chromatography-flame ionization detection (GC-FID), now a routine technique in many laboratories, has been selected as the method for quantification. The protocol described is evaluated, and analyses of sediments from estuaries of the rivers Mersey, Dee, and Tamar, UK, are given as examples of how to interpret results achieved using the technique. (48 refs)

Roberts, P. J. W. 1980. Ocean outfall dilution: Effects of currents. *Journal of the Hydraulics Division,* ASCE, 106(HY5):769-782.

Analyses of data for the city of San Francisco, CA, obtained from continuously recording current meters showed the most energetic current component, the first principal component, to be strongly tidal and to lie along an axis pointing approximately to the Golden Gate. The diffusers were placed perpendicular to this component, where possible, to obtain the maximum beneficial effect of the currents on dilution. A mathematical model was applied to the proposed diffusers to predict dilution in the presence of currents, using measured oceanic conditions. Results show the dilution and wastefield rise height to vary widely due to the varying oceanic and discharge conditions. The median dilutions are found to depend on season and to be increased substantially over those predicted by neglecting the dynamic effect of currents on dilution. The effect of diffuser orientation was also investigated with the model, and it was found that suitable orientation to the prevailing currents can significantly affect the initial dilution. (5 refs)

Rodrigues, A. C., da Silva, M. C., Câmara, A., Fernandes, T. F., and Ferreira, J. G. 1988. Dispersion modelling for a complex estuary--the case of the Tagus. (See complete entry in Section VI.)

Salomão, J. M. 1987. A survey for salinity intrusion and pollution assessment in Maputo Estuary. (See complete entry in Section VII.)

Sanchez-Diaz, E., and Mehta, A. J. 1982. Dispersive transport in inlet channels: Case study. In *Proceedings of the conference applying research to hydraulic practice,* 17-20 August 1982, Jackson, MS, ed. Peter E. Smith, 556-565. New York: ASCE.

The role of a tidal inlet as a "gate" for the exchange of waters between the sea and the bay is important from the point of view of reducing pollutant levels in coastal waters. The nature of transport through the inlet channel, particularly a long one, is a controlling factor which influences the rate of constituent exchange, and therefore the renewal rate of bay waters. An investigation of dispersive transport in the 2.62-km-long Blind Pass channel in Florida was

carried out through dye injection experiments. The dispersion coefficient was determined by comparing the measured temporal and spatial distributions of the dye in the channel with predictions based on a numerical solution of the transport-diffusion equation for a conservative constituent. The value of the dispersion coefficient is found to agree, to a reasonable degree, with the same derived previously using analytic means. It is concluded that transport in the channel is primarily advective. In simple exchange models, channel transport, under conditions similar to those considered, may be assumed to be advective only. (4 refs)

Santschi, P. H., Nixon, S., Pilson, M., and Hunt, C. 1984. Accumulation of sediments, trace metals (Pb,Cu) and total hydrocarbons in Narragansett Bay, Rhode Island. *Estuarine, Coastal and Shelf Science* 19(4):427-449.

The accumulation of sediments, trace metals, and hydrocarbons has been estimated from the analysis of the sediment from six coring sites in Narragansett Bay. Radionuclides ($^{234}Th_{XS}$, $^{210}Pb_{XS}$, $^{239,240}Pu$) with known input functions and trace metals (copper, lead) were used. It is estimated that 6.9×10^4 tons of sediments, 51-90 tons of lead, 72-100 tons of copper and 400-1,000 tons of total hydrocarbons accumulate annually under present conditions in the bay. This represents 64-117 percent (lead), 89-123 percent (copper), and 23-58 percent (hydrocarbons), respectively, of present-day inputs to the bay. Furthermore, close to 100 percent of the particle-reactive radionuclides ^{210}Pb and $^{239,240}Pu$ accumulate in the bay. Present-day inputs to the bay were calculated independently as 77-80 tons lead and 81 tons of copper. Sewage effluents were the dominant source of copper, whereas atmospheric deposition and urban runoff were most important for lead. Dredging activities by the US Army Corps of Engineers between 1946 and 1971 removed more sediments from the bay than would have accumulated during the same time in the undredged areas of the bay. Copper smelting and coal mining on the shores of the upper bay during 1866-1880 left an imprint in the sediments which is still evident. Model-derived accumulation rates of lead, copper, and coal during that time were 3-4 times present-day inputs. (75 refs)

Saxena, P. C. 1983. Effects of reclamation of inter tidal zones in the Mahim Creek. (See complete entry in Section V.)

Sayers, D. R. 1986. Derivation and application of environmental quality objectives and standards to discharges to the Humber Estuary (U.K.). *Water Science and Technology* 18(4/5):277-285.

In November 1983 a set of environmental quality objectives and standards was published for the Humber Estuary. This paper discusses some of the reasons for choosing these particular objectives and standards. It goes on to explain that a mixing zone (within which the objectives and standards may not be met) is permitted around individual effluent outfalls and examines various options for setting the size of that mixing zone. Reference is made to the EC Directive on waste from the titanium dioxide industry and a survey carried out in the summer of 1984 around the effluent outfalls of two titanium dioxide producing factories as an example of a practical application of the EQO approach to pollution control (7 refs)

Segar, D. A., Davis, P. G., and Stamman, E. 1984. A global comparison of contamination in populated estuaries and coastal waters. In *Oceans '84 conference record: Industry, government, education... Designs for the future,* 10-12 September 1984, Washington, DC, 1:284-289. Piscataway, NJ: The Institute of Electrical and Electronics Engineers, Inc.

Many areas of the world ocean which are subject to contaminant inputs from man's waste discharges have been the subject of intensive pollution studies during the last decade. In the United States, the New York Bight Project of the National Oceanic and Atmospheric Administration (NOAA) has been the largest of such marine ecosystem studies. This paper is a brief summary of a study which compared the available information concerning contamination and its effects on the New York Bight and on other coastal areas throughout the world. These comparisons reveal that problems in many regions of the coastal ocean are quite similar, that nutrient-induced eutrophication and organic loading of sediments in areas with insufficient dispersal of inputs are the most widespread and serious problems, and that inputs of toxic trace metals and synthetic organics to the ocean have had no significant impact on human health or the marine environment, except in a few extreme cases in very small areas of the coastal ocean environment. (37 refs)

Seng, L. T., Kwong, L. Y., Chye, H. S., Huat, K. K., Pheng, K. S., Hanapi, S., Meng, W. T.,

Legore, R. S., de Ligny, W., and Tan, G. T. 1987. Effects of a crude oil terminal on tropical benthic communities in Brunei. *Marine Pollution Bulletin* 18(1):31-35.

An environmental survey was carried out in May 1981 at the intertidal and subtidal zone of Sungai (River) Bera, where Brunei Shell Petroleum Company discharges wastewater from its operations. Two reference sites, Sungai Lumut and Sungai Tali, situated northeast of Sungai Bera were also studied. In addition to sampling the macrobenthic communities, hydrocarbon, metal levels, and particle size distribution of the sediments were also studied. Populations of intertidal and subtidal macrobenthic organisms at Sungai Bera were very much lower when compared to those at Sungai Tali and Sungai Lumut. The hydrocarbon levels were highest at Sungai Bera and least at Sungai Lumut. The distribution pattern corresponds well with the levels of hydrocarbons found at the three sites. Hydrocarbons found at the three sites were of petrogenic origin. The effects of the wastewater discharged on the intertidal zone were very localized, confined mainly to Sungai Bera. The hydrocarbon levels at Sungai Tali were almost the same as those at Sungai Lumut. No deleterious effects on the macrobenthic community were detected at these two sites. (16 refs)

Smith, P. E., ed. 1982. *Proceedings of the conference applying research to hydraulic practice.* (See complete entry in Section I.)

Snowden, R. J., and Ekweozor, K. R. 1987. The impact of a minor oil spillage in the estuarine Niger Delta. *Marine Pollution Bulletin* 18(11):595-599.

On 24 April 1984 a barge sank in the Bonny Estuary, spilling 250 barrels of Nigerian crude oil. The incident occurred in an area where a baseline survey was already in progress. These data, plus additional studies at the spill site enabled the impact of the incident to be determined. At the spill site there was a near to total elimination of the littoral infauna and a highly significant oyster mortality, plus a 30 percent oiling of mangrove prop roots and 32 percent oiling of seedlings, which resulted in partial defoliation and death of seedlings within a 500-m^2 area. There were no significant effects on *Uca tangeri* density at the spill site, and no effects at the nearest baseline survey transect 5 km away. The spillage was considered to be minor in terms of the quantity spilled, the effects observed, and their ecological significance. (15 refs)

†**Swanson, J. C.** 1986. A three dimensional numerical model system of coastal circulation and water quality. (See complete entry in Section VI.)

Teeter, A. M., and Pankow, W. 1989. Deposition and erosion testing on the composite dredged material sediment sample from New Bedford Harbor, Massachusetts. (See complete entry in Section II.)

†**The Thames has come alive again.** 1980. (See complete entry in Section V.)

Thompson, G., Neville-Jones, P., and Shahabudin, S. M. 1984. Modelling estuaries for water resources studies. (See complete entry in Section VI.)

†**Tommasi, L. R.** 1985. Mercury pollution in water and sediments of the bay and estuaries of Santos and Sao Vicente. *Ciencia E Cultura* 37(6):996-1001.

Mercury concentration in the surface waters of the Santos Estuary vary between 0 and 7.2 μg/l and between 0 and 4.9 μg/l at the bottom water. Mercury content in the sediment varies between 0 and 8.2 μg/g. Highest mercury concentrations in the water and in the sediment were obtained in the interior of the Santos Channel and in the entrance of Santos Bay. The former area is located close to Cubatao petrochemical and steel industries complex, and the latter region is where the sediment dredged from the channel is deposited.

Tran, D., and Merveille, J. 1986. The problem of brackish water intrusion into inland waterways--The French wateringues area. (See complete entry in Section III.)

†**Trial, W. T., Jr.** 1986. An evaluation of nitrifying activity and unionized ammonia toxicity in a salt-wedge estuary: The Duwamish River Estuary, Seattle, Washington. Ph.D. diss., University of Washington, Seattle.

Nitrification and ammonium in the Duwamish River Estuary, Seattle, were examined using data obtained from laboratory and field measurements. The estuary, a heavily industrialized waterway, receives municipal and industrial wastewater and stormwater discharges. Enumeration of nitrifying bacteria using the most probable number (MPN) method and nitrifier activity measurements using the potential nitrifier activity (PNA) technique showed these organisms to be primarily associated with estuary sediments rather than the water column. Laboratory PNA studies also

revealed that sediment nitrifier activity decreased in a downstream direction in response to saline conditions. Twice-daily incursions of a saltwater wedge appeared to account for a marked decline in sediment nitrifier activity over approximately a 6-km reach of the estuary. The in situ rate of nitrification measured in the estuary was calculated based on the increase in NO_2- + NO_3-N during a time of travel survey down the river. This rate is considered to be best represented by a zero-order sediment-based process expressed on an areal basis as 725 mg m^{-2} day^{-1}. Such findings indicate that in flowing water systems containing a relatively high ammonium content (approximately 2 mg l^{-1}) the use of first-order reaction kinetics to describe nitrification cannot be assumed. Nitrification in vitro was determined in chambers containing water and sediment collected from the estuary. Rates of nitrification were observed to decrease when sediments of the lower estuary were in contact with low (4°/oo) versus high (20°/oo) salinity water. Interstitial ammonium in sediments of the lower study reach (below km 10) was shown to be higher than that in the overlying water column while this gradient was reversed in the upper study reach (km 21-10). Experimental results in vitro showed sediments of the lower estuary to release ammonium to the water column. An increase in the concentration of un-ionized ammonia (NH_3) was calculated based on the projected increase of secondary effluent discharged to the estuary. An increase in NH_3 to toxic levels may occur but only if phytoplankton bloom activity increased instream pH to 8.5 or greater.

Ukita, M., Nakanishi, H., and Sekine, M. 1988. Study on transport and material balance of nutrients in Yamaguchi Estuary (Japan). (See complete entry in Section VI.)

Vongvisessomjai, S., and Charuskumchornkul, S. 1989. Boundary conditions of tidal model at river mouth. (See complete entry in Section VI.)

†**Wagner, F., and Hart, D.** 1986. Urban estuarine systems under stress: Environmental issues facing Louisiana's Lake Pontchartrain. *The Environmentalist* 6(1):25-33.

Lake Pontchartrain is part of a brackish coastal estuarine system. Seafood extraction, shell dredging, and leisure time activities are the major uses occurring on Lake Pontchartrain. In the past several decades, man has severely altered this system through urbanization, industrial activity, levee construction, and subsequent destruction of wetlands surrounding the lake. There is a growing awareness of the environmental crisis facing Lake Pontchartrain, advanced by recent fish kills, detection of toxic chemicals, curtailment of recreational opportunities, and the report of "dead zones" in the lake. This study summarizes a series of international environmental management techniques and examines the utilization of a regional structure for water resources management in the Lake Pontchartrain Basin. (18 refs)

Walton, R., Kossik, R., Adams, E., and Cosler, D. 1989. Far-field numerical model studies for Boston's new secondary treatment plant outfall siting. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 1017-1022. New York: ASCE.

By the late 1900's Boston is scheduled to have built a new secondary treatment plant that combines the waste streams from two existing plant, and discharges the resulting liquid effluent through a long outfall to Massachusetts Bay. The plant will be designed to discharge over 53 m^3/sec (1200 mgd) through a 2,000-m diffuser into 30 m of water, approximately 13-16 km offshore. The objective was to site an outfall diffuser to maximize initial mixing and reduce the likelihood of discharged effluent returning to shore in high concentrations. An extensive field program was completed in order to understand system processes, and to calibrate circulation and transport models of the area. (5 refs)

Wang, S. Y., Shen, H. W., and Ding, L. Z., eds. 1986. *River sedimentation.* (See complete entry in Section II.)

Weishar, L. L., and Fields, M. L. 1985. Annotated bibliography of sediment transport occurring over ebb-tidal deltas. (See complete entry in Section II.)

†**Wen, C.-G., Kao, J.-F., Wang, L. K., and Wang, M. H.** 1983. Sensitivity analysis of ecological design parameters in streams: Part B. *Civil Engineering for Practicing and Design Engineers* 2(6):537-550.

The sensitivity equations of stream water quality parameters are presented, and their practical applications to stream pollution control scientifically illustrated. Tidal streams are classified into (a) clean or slightly polluted tidal streams, (b) moderately polluted tidal streams, and (c) heavily polluted tidal streams. The characteristics and water quality

parameter ranges of different types of receiving streams are presented. The significance of water quality sensitivities and dissolved oxygen deficits are systematically identified. (14 refs)

West, J. R., and Mangat, J. S. 1986. The determination and prediction of longitudinal dispersion coefficients in a narrow, shallow estuary. (See complete entry in Section VIII).

Wharfe, J. R., Dines, R. A., and Bird, L. A. 1986. The environmental impact of paper mill waste discharges to the Upper Medway Estuary, Kent, England. *Environmental Pollution (Series A)* 40(4):345-357.

The Upper Medway Estuary is considered as the narrow, funnel-shaped channel from the tidal limit at Allington downstream to Lower Upnor. Mathematical models are used to predict the depletion of dissolved oxygen resulting from organic waste inputs to the upper estuary. Surveys of the soft sediment fauna together with sediment redox potentials and organic carbon and cellulose content showed that conditions were generally poor and that faunal diversity was low, although a few surviving oligochaetes proliferated in the absence of predation and competition, with numbers in excess of 1.0×10^6 individuals per m^2 of sediment being recorded. The bottom sediments were relatively mobile, although a combination of sediment organic content and redox potential profiles clearly demonstrated the occurrence of reduced sediment conditions at depths below 6 cm at some sites in the upper estuary, with the greatest effect at sites downstream of the paper mill discharges. A significant reduction in the amount of organic waste discharged to the upper estuary should increase faunal diversity, although high species richness is considered unlikely given the naturally harsh conditions. (10 refs)

Whitelaw, K., and Andrews, M. J. 1988. The effects of sewage sludge disposal to sea--The Outer Thames Estuary, U.K. *Science and Technology* 20(6/7):183-191.

Sewage sludge disposal in the Outer Thames estuary is the largest operation of its kind in the United Kingdom. This paper reports interim results from a 4-year study of the effects of this sludge upon the environment of the outer estuary. Using radiolabelled sludge and fecal bacteria, the sludge was shown to disperse widely soon after disposal. Dispersion in the sediments is being followed over a period of 1 year. Mussels placed in cages along the known dispersion path of sludge in the water column exhibited sublethal physiological stress. However, the benthic infauna distributions were shown to be related principally to sediment characteristics and no effect due to sludge could be detected. The incidence of epidermal diseases in fish was low, and that from the vicinity of the disposal ground was similar to that from a nearby commercially fished area to which the sludge did not disperse. (14 refs)

Wiley, M. L., ed. 1978. *Estuarine interactions.* (See complete entry in Section II.)

Wood, P. C., and Abel, R. 1986. Inputs into the North Sea and their effects. *Water Pollution Control* 85(2):208-215.

As part of the preparation for the International Conference on Protection of the North Sea concluded in Bremen in October 1984, coastal states contributed to a scientific study of the North Sea, in order to provide a basis for discussions. This paper is based upon contributions made by UK scientists to that study, but concentrates mainly on the inputs and effects of discharges from the UK. However, some wider issues affecting the health of the North Sea are also addressed. The North Sea is subject to a substantial inflow of water through the English Channel and between Norway and the north of Scotland, and hence there is a comparable compensating outflow of water via the Norwegian coastal current. Along the British east coast, tidal currents can exceed 2 knots and there is a very vigorous vertical mixing. These water movements play a major part in the mixing and dispersal of soluble and insoluble pollutants discharged to British coastal waters. The main sources of inputs are rivers, sewage, and industrial discharges to coasts and estuaries, dumping discharges associated with offshore platforms and shipping, and the atmosphere.

Wright, D. A., and Phillips, D. J. H. 1988. Chesapeake and San Francisco bays: A study in contrasts and parallels. *Marine Pollution Bulletin* 19(9):405-413.

Among coastal waters, estuaries are of unique importance to the human population. The topography of estuaries lends itself to their use for waterborne trade, providing sheltered waters. Freshwater inflows are a prime source of drinking and irrigation waters. The biological resources of estuaries are employed to feed growing populations around their margins. As a result of these and other factors, estuarine areas have generally become the

most heavily developed of all coastal regions. Such urbanization has given rise to many changes, and estuarine waters are frequently thought to be those most at risk from pollution and the inappropriate use of natural resources. Chesapeake Bay and San Francisco Bay are among the largest extended estuarine systems in the continental United States. Their comparison provides a most interesting study in contrasts and parallels. This paper reviews the main features of each estuary and discusses estuarine topography, hydrodynamics, and nutrient input, estuarine water quality, trace metals and organic contaminants, and biological resources. (48 refs)

†**Yanagi, T.** 1984 Sediment transport by tidal residual flow in bays. (See complete entry in Section II.)

Zingde, M. D., and Mandalia, A. V. 1988. Study of fluoride in polluted and unpolluted estuarine environments. *Estuarine, Coastal and Shelf Science* 27(5):707:712.

Mindhola River Estuary, which receives industrial waste containing high concentrations of fluoride, and Purna River Estuary, which is free from fluoride contamination, have been investigated. While fluoride behaved conservatively in Purna River Estuary, significant deviation from the theoretical dilution line (TDL) in the chlorinity range 0.5-8°/oo was observed in Mindhola River Estuary due to the externally added fluoride which largely remained in solution. The excess of fluoride over the theoretically calculated value was at a maximum around a chlorinity of 3°/oo. High natural fluoride content of the river waters resulted in fluorine-chlorine ratios exceeding 300×10^{-5} at low chlorinities. The ratio decreased rapidly with increasing chlorinity and the value near to that of seawater was observed at chlorinities above 14°/oo. (13 refs)

Zingde, M. D., Narvekar, P. V., Sharma, P., and Sabnis, M. M. 1986. Environmental studies of the Ambika and associated river estuaries. *Marine Pollution Bulletin* 17(6):267-274.

The tide-dominated coastal plain Ambika, Kaveri, and Kareira estuarine system has been investigated to evaluate the influence of industrial and domestic wastewater discharges on the water quality. The wastewater streams were gaged and the pollution loads quantified. High seawater influx, strong currents, and small low-tide volume rendered the estuaries well mixed with excellent flushing characteristics. Although a tidal range of 1.2 m (spring) was observed 20 km inland, there was no intrusion of saline water except in May. The estuarine zone is characterized by high and variable suspended load. Nutrients, pH, and trace metal concentrations in water were the natural background levels. The high biochemical oxygen demand (BOD) (24,600 kg/day) and the riverine flow influenced the distribution of dissolved oxygen in the Ambika Estuary to a considerable extent. (12 refs)

Zingde, M. D., Sharma, P., and Sabnis, M. M. 1985. Physicochemical investigations in Auranga River Estuary (Gujarat). *Mahasagar* 18(2):307-321.

The wastewater streams polluting the Auranga River Estuary were sampled periodically and pollution loads were quantified. The shallow estuary is well mixed with excellent flushing characteristics due to the high seawater influx and strong tidal currents. The flushing time calculated (2.7-4.1 tidal cycles) by applying the fraction of freshwater method was at least three times higher than computed on the basis of the tidal prism method. The load retained in the estuary under continuous flow of pollutants and after a large number of tidal cycles was estimated to be less than 3 times the load introduced per tidal cycle. The suspended load in the estuary varied with the current speed and was mainly due to the dispersion of the bottom sediment into the water column.

SECTION V. REGULATION AND IMPROVEMENT

Examples and histories of prototype improvements, types and locations of improvements, materials and designs of structures, construction practices, dredging, and the practical aspects of regulation and improvement for navigation, sedimentation, and contamination, and other purposes, as contrasted to the theoretical aspects.

Aggerholm, D. A. 1989. Sediment regulation in Puget Sound. (See complete entry in Section II.)

Andrassy, C., and Herbich, J. B. 1988. Generation of resuspended sediment at the cutterhead. *The Dock & Harbour Authority* 68(797):207-216.

This article was presented as a paper at the 20th Texas A&M University Dredging Seminar held in Toronto, Canada, on 23 September 1987. Dredging of the Nation's navigable ports and waterways has been and will continue to be a necessary activity in order to maintain sufficient depth for the safe passage of ships. This dredging is often performed by the cutterhead dredge, one of the most versatile and widely used dredges in the world. Over the years, many of the sediments in these ship channels, ports, and harbours have accumulated toxic substances as a result of river commerce, industrial activity, increased use of pesticides, and the dumping of pollutants. When dredged, varying amounts of these contaminated sediments are resuspended in the water. In general sediment resuspension is the primary means by which contaminants are transferred to the water column. When dredging contaminated sediments throughout the water column, the contamination can be dangerous to marine plants and animals, as well as humans. The source of such contamination, resuspension at the cutterhead, is believed to be a function of environmental conditions, dredge plant and sediment characteristics, and the operating parameters of the dredge. This article examines the relationship between dredge operating parameters and suspended sediment levels generated at the cutterhead for several model and field studies which have been conducted. In each case, dimensional analysis is used to form dimensionless groups of operating parameters, dredge characteristics, and sediment characteristics which were monitored along with the suspended sediment levels at the cutterhead. Parameters used in the analysis include rotational speed, suction velocity, swing velocity, thickness of cut, ladder angle, sediment size, and cutter size. Scatter diagrams are conducted for the various dimensionless parameters and the sediment concentration at the cutterhead. Regression analysis is performed to determine the statistical significance of the correlations. (17 refs)

Badenhorst, P. 1986. Effect of dredging on estuarine environments, alternative disposal sites and dredging guidelines. CSIR Report T/SEA 8613. Stellenbosch, South Africa: National Research Institute for Oceanology, Council for Scientific and Industrial Research.

This report summarizes the various effects of dredging on estuarine environments and alternative methods of dredge spoil disposal with conclusions, and recommends dredging guidelines for dredging applications. (2 refs)

Bales, J. D. 1989. Land drainage and estuarine salinity response. (See complete entry in Section III.)

Bales, J. D., and Holley, E. R. 1989. Sand transport in Texas tidal inlet. (See complete entry in Section II.)

Banal, M. 1982. Tidal energy in 1982 (L'énergie marémontrice en 1982). *La Houille Blanche* 37(5/6):433-439 (In French).

The paper recalls that the Rance station remains, 15 years after its commissioning date, the only large tidal power station in the world. It provides information on the state of the installations and operating conditions, updating the data presented at the November 1972 session of the technical committee of the French Hydraulics Corporation (SHF), and published in issue 2/3 of *La Houille Blanche* in 1973. The paper also recapitulates the main sites and tidal power stations projected throughout the world and discusses the characteristics such a list must have for it to serve its purpose. It mentions five major recent developments in the field of tidal energy: publication of the results of a major study of the development of the Severn (United Kingdom), the order for a test generating set for Annapolis (Canada), completion of the feasibility study of Garolim (South Korea), the initiation of feasibility studies of the Kutch plant (India), and the resumption of studies in France. It then describes certain aspects of the current orientation of French studies. (3 refs)

Banal, M. 1989. Tidal energy in 1989 (L'énergie marémontrice en 1989). *La Houille Blanche* 6:435-442 (In French).

In the 5/6-1982 edition of *La Houille Blanche* under the title "Tidal Power in 1982," the author presented a large range of plans and achievements relating to this power throughout the world. In this article he discusses the situation in 1989.

Berger, R. C., Jr., Heltzel, S. B., Athow, R. F., Jr., Richards, D. R., and Trawle, M. J. 1985. Norfolk Harbor and channels deepening study; Report 2, Sedimentation investigation; Chesapeake Bay hydraulic model investigation. (See complete entry in Section II.)

Bernshtein, L. B. 1988. From experimental to large tidal power stations (20th anniversary of the Kislogubsk tidal power station). (See complete entry in Section VI.)

Bernstein, L. 1986. Tidal power engineering in the USSR. (See complete entry in Section VIII.)

†**Besnier, G.** 1983. Equipment of the estuary of the Vilaine; Building of Arzal Dam (L'amenagement de l'estuaire de la Vilaine; Construction du Barrage d'Arzal). *Techniques et Sciences Municipales Eau* 3:99-108 (In French).

Coastal zones frequently raise problems as to their fresh water supply. On the other side, tidal estuaries on the Atlantic Coast, with backflows of sea water for tens of kilometres inland, and at the same time the settling of resuspended marine sediments which are deposited downstream of the tide, are the object of uninterrupted works in order to control both these nuisances. The building of a dam on the estuary, as near as possible to the outlet into the sea, enables the solution of all these problems: stopping the silt-loaded salt flow, and constitution of a fresh water reserve upstream. This was realized on the river Vilaine at Arzal, 8 km from the mouth. The structure enables stocking 35,000 cu m, secures the release of highwater with 2,000 cu m/sec, and protects the lower parts of the town of Redon against floods resulting from the conjunction of a flood and a spring tide. Its realization was specially critical, as the levee, which completes the spillways, rests on marine silts 26 m thick.

Blaauw, H. G., Lindenberg, J., Strating, J., and Vellinga, P. 1983. Numerical models in port design. (See complete entry in Section VI.)

Bliek, A. J., Klatter, H. E., Konter, J. L. M., and van der Meulen, T. 1986. Short cut channels in tidal estuaries. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:300-309. University, MS: University of Mississippi.

The development of short cut channels was investigated in the Eastern Scheldt in The Netherlands. Predictions related to the formation of short cut channels are essential for the control of morphological and hydraulic developments in the estuary during the construction of a storm surge barrier. Application of modern modelling techniques was the basis for these predictions. The results of these predictions are discussed in this paper and are compared with the actual morphological and hydraulic developments in nature in order to demonstrate the applicability of advanced modelling techniques to the design and execution of large projects.

Boesch, D. F., Day, J. W., Jr., and Turner, R. E. 1984. Deterioration of coastal environments in the Mississippi Deltaic Plain: Options for management. In *The estuary as a filter,* ed. V. S. Kennedy, 447-466. Orlando: Academic Press.

Coastal environments in the Mississippi Deltaic Plain of southeastern Louisiana are undergoing rapid change as a result of natural decay of Mississippi delta lobes, channelization of river flow, and dredging activities. As a result, over 100 km^2/year of coastal wetlands are converted to open water or uplands--85 percent of the total US loss rate. Of the options available to reduce the deterioration of coastal wetlands, management of new delta accretion and regulatory control and rehabilitation of channelized wetlands are likely the most effective. Attempts to stabilize coastal barriers should also be made because of the potential for very rapid erosion in their absence. Controlled diversions of the river above the active deltas will be limited in capacity by the presence of populated areas and roads and are unlikely to contribute significantly to new wetland accretion. (34 refs)

Bottin, R. R., Jr., Outlaw, D. G., and Seabergh, W. C. 1985. Effects of proposed harbor modifications on wave conditions, harbor resonance, and tidal circulation at Fish Harbor, Los Angeles, California; Physical and numerical model investigations. (See complete entry in Section VI.)

Brady, J. A., Stead, R. G., and Ord, W. O. 1983. Pollution control policies for the Tees Estuary. (See complete entry in Section IV.)

Butler, H. L. 1982. Numerical modeling of inlet-estuary systems. (See complete entry in Section VI.)

Castillo, F. P. 1983. Historical coastline changes at the southern shore of the Gulf of Venezuela. In *International conference on coastal and port engineering in developing countries,* 20-26 March 1983, Colombo, Sri Lanka, I:16-25. Colombo, Sri Lanka: Conventions (Colombo) Ltd.

This paper examines the historical changes to the coastline around the islands of the entrance to Lake Maracaibo, Venezuela. It describes the studies

conducted to determine the sediment transport changes and effects on the navigation channel. A numerical model which estimates inlet velocities and bay water levels for tidal sea fluctuations is used. (5 refs)

Chu, Y.-H., and Chen, H. S. 1985. Bechevin Bay, Alaska, inlet stability study. (See complete entry in Section VI.)

Cialone, M. A. 1986. Yaquina Bay, Oregon, tidal and wave-induced currents near the jettied inlet; Numerical model investigation. (See complete entry in Section VI.)

Copeland, R. R. 1986. San Lorenzo River sedimentation study; Numerical model investigation. (See complete entry in Section VI.)

Crash program fights tides. 1989. *ENR* 223(17):26-27.

This brief article describes the successful efforts by the public and private sectors in South Carolina to build protective sand dunes along portions of the coast flattened by Hurricane Hugo in fighting off a once-a-decade high tide.

Cuff, W. R., and Tomczak, M., Jr., ed. 1983. *Synthesis and modelling of intermittent estuaries; A case study from planning to evaluation.* (See complete entry in Section VI.)

Daborn, G. R. 1985. Environmental implications of the Fundy Bay tidal power development. *Water Power & Dam Construction* 37(4):15-19.

Barrage construction in the basins which have the world's highest tides (more than 16 m) is expected to increase the biological productivity of the impoundment, to increase the tidal range and mixing in the Gulf of Maine some 300 km away, and to endanger important migratory bird and fish populations. Assessment of environmental effects is based on close cooperation between environmental scientists and engineers. (14 refs)

†**Daiber, F. C.** 1986. *Conservation of tidal marshes.* New York: Van Nostrand Reinhold.

This book gives professionals concerned with the tidal marsh ecosystem the hands-on guidance they need to maintain and restore depleting coastal resources. Concentrating on temperate North American east coast marshes and those of western Europe, this handbook offers insight into water management, ecological effects of insecticides, effects of chronic oil spills, and management philosophies. Information is included on open marsh management, wastewater disposal, and waste treatment. Largely experimental but highly consequential management concepts are examined that have been developed in recent attempts to restore, enhance, and control the tidal wetland ecosystem. Viable solutions to the wetland problem are presented.

Delft Hydraulics Laboratory. 1986. Special issue on estuaries and coastal seas. (See complete entry in Section VI.)

Delo, E. A., and Burt, T. N. 1986. Dispersion of sidecast dredge spoil: A mathematical prediction and field study. In *XIth world dredging congress,* 4-7 March 1986, Brighton, UK, ed. J. H. Volbeda, V. L. van Dam, and N. Oosterbaan, 517-528. Delft, The Netherlands: Central Dredging Association.

This paper describes a series of mathematical models developed to simulate the short-term dispersion of dredged spoil in an estuary or at sea. Spoil from dredging operations is often disposed of by transporting the material to a spoil ground and discharging it from the hopper. Alternatively, the material can be discharged directly over the side of a working dredger in an operation known as sidecasting. In the latter case the effectiveness of the method depends on the existence of suitable crosscurrents to carry the sediment away from the dredge site before it returns to the bed. The models predict the "footprint" of dredged material that may be expected to be found downdrift of its release point as a result of sidecast operations. They were tested against results obtained during dredging operations in the Severn Estuary. The results showed that the models were able to simulate the pattern of deposition resulting from the sidecast discharges. (10 refs)

†**De Young, B. S.** 1986. The circulation and internal tide of Indian Arm, B.C. (See complete entry in Section I.)

DiLorenzo, J. L., Huang, P.-S., and Najarian, T. O. 1989. Water quality models for small tidal inlet systems. (See complete entry in Section VI.)

Douglass, S. L. 1987. Coastal response to jetties at Murrells Inlet, South Carolina. *Shore & Beach* 55(2):21-32.

Murrells Inlet is a tidal inlet on the Atlantic coast

about 15 miles southwest of Myrtle Beach, South Carolina. The inlet provides tidal flow between the ocean and a 2,500-acre estuary and serves both small craft and commercial fishing industries. The area is part of South Carolina's "Grand Strand," the coastal resort communities centered at Myrtle Beach. On the north side of the inlet is the town of Garden City Beach, a rapidly developing coastal resort with many private boat docks and ramps. Commercial and charter fishing outfits and several small-boat marinas with public boat ramps are located on the east side of the estuary in the town of Murrells Inlet. These boats use the inlet to get to and from the Atlantic Ocean. South of the inlet is Huntington Beach State Park, with camping and picnicking facilities and almost 4 miles of ocean beach. South of the state park is the community of North Litchfield Beach. Geologically, the "Grand Strand" is the mainland ocean beach from just north of Murrells Inlet to just south of Little River Inlet on the North Carolina-South Carolina border. There are no barrier islands on this stretch of coastline: the beach is part of the mainland. The strand is broken by many small streams which are maintained by the tidal flow to small (several-acre) estuarine areas called sloughs. These sloughs are fed by small local rainfall runoff. These breaks in the beach are often choked off by longshore sand transport and do not provide any navigable access to the ocean. Murrells Inlet and Little River Inlet have historically been sand choked and very mobile inlets. Both inlets have been stabilized by jetties. This paper discusses the coastal processes at Murrells Inlet during the first 5 years following construction of the jetties. The coastal response to the jetties is characterized as an approach toward a new equilibrium similar to what has occurred at other east coast inlets. The longer term longshore sand transport climate is also investigated. (12 refs)

Douglass, S. L. 1987. Coastal response to navigation structures at Murrells Inlet, South Carolina: Main text and appendixes A and B. (See complete entry in Section VIII.)

Draper, C. 1982. Thames Barrier Project. *Dredging and Port Construction* 9(1):21, 23-25, 27-28, 32-33.

The basic design concept and the civil engineering works involved in this project are described. The Thames Barrier will give protection to 45,000 square miles in the London area against tidal floods.

Dyson, A. R., and Druery, B. M. 1985. The impact of sand extraction on salt extrusion in the Hawkesbury River. (See complete entry in Section III.)

†Eisma, D., Gaast, S. J. van der, Martin, J. M., and Thomas, A. J. 1978. Suspended matter and bottom deposits of the Orinoco Delta: Turbidity, mineralogy and elementary composition. (See complete entry in Section II.)

Everts, C. H., and Hartman, G. 1986. Effect of jetty construction on the ocean entrance of the Columbia River. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:1174-1180. University, MS: University of Mississippi.

Jetties have had a major and continuing effect on sedimentation at the mouth of the Columbia River. Sand scour between the jetties began immediately after construction. The cause was enhanced current velocities as a consequence of flow constriction. Sand movement was predominantly seaward coincident with times when tidal flow (ebb) and freshwater discharge were additive. The creation of a large offshore bar (Outer Bar) seaward and north of the entrance was the result. After reaching its maximum volume the Outer Bar began degrading at perhaps 0.1 times the rate at which it formed. Degradation was caused by shore-parallel sand transport at a rate initially about equal to the present net longshore sediment transport rate to the north. South of the South Jetty the beach and shoreface have been losing sand at about that rate. Sand from the south, however, is transported over the South Jetty to a depositional site between the jetties. This material is primarily responsible for the present sedimentation problem on the south side of the navigation channel (Inner Bar). Although the sedimentation rate has increased as channel depth was increased, the cause appears to be temporary. When the channel was deepened by dredging, the bottom surface outside and away from the deepened channel boundaries adjusted to the new deeper condition as the sloping surface dropped a distance equal to the channel depth increase. Large quantities of sand were thus eroded and carried to the channel and deposited. Almost all sand-sized material that presently reaches the entrance is deposited there. Present sand volumes

arriving from upriver are small. The effect of the jetties has been overwhelmingly positive in the context of maintaining the navigation channel. (3 refs)

Eysink, W. D., and Vermaas, H. 1983. Computational methods to estimate the sedimentation in dredged channels and harbour basins in estuarine environments. In *International conference on coastal and port engineering in developing countries*, 20-26 March 1983, Colombo, Sri Lanka, II:1072-1083. Colombo, Sri Lanka: Conventions (Colombo) Ltd.

When the construction of a new harbor or the improvement of an existing harbor for larger ships is considered, a study will, in many cases, also include a sedimentation study to predict the future cost of maintenance dredging as an important figure in the economic feasibility of the project. In the past, various tools to predict the sedimentation rates in dredged areas have been presented. The methods varied from a simple empirical formula to various types of mathematical models. Generally, all prediction methods are valid for restricted conditions only, where the mathematical models are expected to achieve, at least to some extent, more reliable results. However, the advantages of mathematical models relative to more simple methods are often offset by the uncertainties in important basic field data like sediment transport, sediment concentrations, and fall velocities of suspended sediment. In such cases, only simple computations are applicable or when a rough estimate is considered adequate. Therefore, the Delft Hydraulics Laboratory also has developed a set of rather simple computational methods, which are based on simplified theoretical considerations introducing basic relations between sedimentation, dimensions of the dredged area, sediment characteristics and hydraulic conditions. Keeping in mind the restrictions, the formulas presented in this paper can be valuable tools in the hands of an experienced hydraulic engineer to predict sedimentation rates in dredged channels and basins in an estuarine environment. (15 refs)

Fagerburg, T. L. 1989. Winyah Bay, Georgetown, South Carolina, data collection survey report. (See complete entry in Section VIII.)

Fleming, C. A., and Simpson, J. 1986. Studies for and design of dredging and reclamation for a new port. In *XIth world dredging congress,* 4-7 March 1986, Brighton, UK, ed. J. H. Volbeda, V. L. van Dam, and N. Oosterbaan, 529-539. Delft, The Netherlands: Central Dredging Association.

This paper describes the planning, investigation, design, and tender documentation stages of the dredging and reclamation for the new deepwater port of Songkhla, Thailand. The port comprises three berths located on a reclaimed area which will be formed mainly from material to be dredged to form the 6-km-long entrance channel and harbor basin. It may be necessary to supplement fill by imported material. The bed material comprises a large proportion of silty sands and clayey sands as would be expected in the region of the ebb tide delta of the tidal inlet, and these materials would be unsuitable for use in the reclamation. Environmental protection was a major consideration, requiring the preparation of an Environmental Impact Statement (EIS). The effect on the benthos of the dredging and reclamation activities was also investigated. Major factors influencing the design were the results of the mathematical and physical models which were conducted for the project. The suite of mathematical models, which comprised a wave refraction model, a channel infill model, and beach plan shape model, is outlined. (2 refs)

Flood barrier blocks tidal surges; Twin towers drop gate into English river. 1980. *Engineering News-Record* 204(18):29-30.

After conquering a cramped site and unforeseen soil problems, British builders have put the finishing touches on a tidal surge barrier now poised to stem the periodic flood tides that sweep into the eastern English seaport of Kingston upon Hull. The barrier is needed because high tides backed by strong northerly winds produce tidal surges in the North Sea that have flooded parts of the area several times during the past decade.

Franzius, O. 1986. Suspended sediment problems in the brackish transition of the tidal Ems River. (See complete entry in Section II.)

Gascoine, I. S., and Jury, K. M. 1984. The development and use of a theoretical mathematical model for the Medway Estuary. (See complete entry in Section VI.)

†**Gavaghan, H.** 1986. Time and tide are right for the Severn Barrage. *New Scientist* 111(1517):21-22.

This article presents a brief discussion of the projected scheme for a barrage across the Severn Estuary and its tidal power capacity.

†**Government cast revises interest in tidal barrage schemes.** 1986, *Energy Management* Aug:4-5.

UK Government-funded research into tidal resources and feasibility studies for tidal power schemes on the rivers Severn and Mersey are reported. The two possible barrage schemes on the Severn Estuary are outlined with details of construction and electricity costs. A feasibility study will be set up on the Mersey to investigate navigation and locks, hydraulics, sedimentation, environmental impact, and social and industrial effects. This proposed scheme is likely to be commercially viable and can be funded from the private sector. Two locations are being considered and a brief description of the proposed scheme is given. Sluices will allow the incoming tide to flow up the river. When the downstream water level has fallen to provide a hydrostatic head, the turbines will be opened to generate power.

Grad, P. 1986. Jet pumps keep passage clear of tidal sands. (See complete entry in Section II.)

Granboulan, J., Villerot, M., Chaumet-Lagrange, M., Reau, J. P., and Henaff, G. 1989. Recent developments in data collection and processing applied to channel maintenance; The case of the Gironde Estuary. In *Dredging: Technology, environmental, mining; Proceedings of WODCON XII,* 2-5 May 1989, Orlando, Florida, 372-396. Irvine, CA: World Dredging Mining and Construction.

The port of Bordeaux Authority is responsible for channel maintenance and operations in the Gironde, largest estuary in Europe with a channel over 100 km long. So as to reduce the cost of maintenance dredging, the port has developed new systems in the field of data collection and processing using the most recent developments in electronic and microcomputer technology. The paper describes the system developed by the port of Bordeaux to improve:
(a) hydrography (on board data collection, automatic plotting of sounding sheets,...), (b) dredging (load recording, positioning, optimal dredging productivity,...). The improvements in productivity resulting from these systems are evaluated in the paper. (10 refs)

Greenberg, D. A. 1987. Modeling tidal power. (See complete entry in Section VI.)

Gusman, S., and Huser, V. 1984. Mediation in the estuary. *Coastal Zone Management Journal* 11(4):273-295.

Certain key disputes remained unresolved after extensive and for the most part successful efforts by the Columbia River Estuary Study Taskforce (CREST) to develop a management plan for the Columbia River Estuary and its shorelands. The remaining disputes, involving conflicts between resource protection and port development, were resolved by the mediation process described in this paper. This process, involving exploration, process design, negotiation, and implementation phases, led to the signing of an agreement by twelve negotiators, the subsequent endorsement of the agreement by the Federal, State, and local governmental bodies they represented, and the incorporation of the terms of the agreement into the comprehensive plans of local governments. The agreement describes the particular kinds of port-related development that might be appropriate at specific sites in the estuary and the conditions under which such development might take place. It also outlines areas where development alteration would not occur. For some of the sites it presents constraints on dredge-and-fill activities, turning basin and navigation channel depths and widths, corridors for pile-supported causeways and accessways, and mitigation policies. (26 refs)

Halliwell, A. R. 1986. Engineering model for well-mixed tidal basin. (See complete entry in Section VI.)

Hamm, L. 1986. Analysis of the evolution of beds in the Seine Estuary (Analyse de l'evolution des fonds dans l'estuaire de la Seine). (See complete entry in Section VI.)

Hamm, L., Barailler, L., Rambaud, B., and Hauville, S. 1986. Analysis of sediment load in the navigation channel of the Seine Estuary. (See complete entry in Section VI.)

Heywood, P. 1986. Dutch win war with the North Sea. (See complete entry in Section III.)

Homsi, A. 1986. Port of Itajai and Itajai-Acu Estuary sedimentation and erosion studies. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:497-506. University, MS: University of Mississippi.

Since 1981 the INPH has been studying the sedimentation problems of the Itajai Port, constructed along 700 m of the right bank of the Itajai-Acu River Estuary with the upstream 300 m of quay stretching

along the most upstream concave side of a bend and having a downstream limit being some 3.4 km distant from the ocean, looking for ways to diminish dredgings necessary to maintain adequate depths for the estuary and the entrance channel. In July of 1983 an extreme flood occurred, causing abnormal erosions in the pools and depositions in the point bars, destroying completely 87 m of the most upstream part of the quay, seriously damaging 276 m of the immediate downstream quay, and increasing by three the volume of the north bank at the entrance of the estuary. From this after-flood framework, an extensive field measurement program and some model studies were suggested and executed. This paper presents a detailed analysis of the bathymetric charts, correlating with river discharges; man-made interference such as dredging and training and cutoff works; and extreme events, giving emphasis to a sedimentation study for the quay channel, turning basin, estuary channel, and the entrance channel across the bar, considering the bathymetric evolution, dredging volumes, and measurement of concentration of suspended sediments, along the most active period of measurements of November 1983 to October 1984. (13 refs)

Horner, R. W. 1985. The Thames Barrier. *Proceedings of the Institution of Civil Engineers*, Part 1, 77:15-25.

This article discusses the need to build the Thames Barrier; the consequences of the adverse change of high waters by the occurrence of exceptional surge tides on the east coast of England from time to time; and the aspect which made the construction of the Thames Barrier essential, i.e., the built-up area which was at risk of serious flooding should a high surge tide enter the Thames Estuary. It further discusses the design of the barrier and construction. (5 refs)

Huval, C., Comes, B., and Garner, R. T., III. 1985. Ship simulation study of John F. Baldwin (Phase II) Navigation Channel, San Francisco Bay, California. Technical Report HL-85-4. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

The WES Research Ship Simulator was used to evaluate the design of Phase II of the John F. Baldwin Ship Channel and to study the impact of the deepened channel on the navigability of large tankers inbound to the Long Wharf docking facility near Richmond Harbor. The present channel and maneuvering area is 35 ft deep and is inadequate for the larger tankers bringing crude oil from the Alaskan North Slope. The San Francisco District has proposed to deepen the channel to 45 ft deep. The authorized 35-ft-deep channel was simulated to verify the ship simulator setup as well as establish the base maneuvering strategies, and the proposed 45-ft-deep channel was simulated to study the proposed conditions. In addition to the tankers, containerships navigating into Richmond Harbor entrance channel were also simulated to investigate the impact of channel deepening on other ships using the maneuvering area. The proposed project will allow fully laden 87,000-dwt and partially laden 150,000-dwt tankers to unload at the Long Wharf. Present tanker operations require all but the smallest tankers to anchor in the main bay and off-load a substantial part of the cargo into shallower draft tankers that can be accommodated with the 35-ft-deep channel. The proposed channel will reduce transportation costs as well as reduce the possibility of oil spills in San Francisco Bay. As a part of the project, a reconnaissance trip was made to observe ship and pilot operations and to record the inbound trip into the Long Wharf maneuvering area on a typical tanker presently using the channel. The channel geometry, the overbank depths, and the visual scene were then developed for the simulator using maps and photographs of the project area. All important visual information was included so as to provide the proper visual cues to the pilot conning the ship. Special tests were conducted on the San Francisco Bay-Delta Model to gather realistic tidal current data for input into the ship simulator. All simulations were run with a 20-knot wind blowing from the southwest. Tests for the base and proposed channel conditions were conducted using 87,000-dwt partially laden (30-ft draft) and 150,000-dwt partially laden (40-ft draft) tankers, respectively. Both flood and ebb current conditions were simulated. In addition to ship track plots, several other critical parameters were plotted and studied, such as ship speed and docking posture as it approaches the Long Wharf. The main containership used to simulate future size ships calling at Richmond Harbor was 810 ft long and 106-ft beam loaded to a 32-ft draft. A smaller containership with 638-ft length and 100-ft beam was also used to simulate present-day ship sizes. Test results indicate that it is very important to reduce tanker speed in Southampton Channel for inbound transits to about 5 knots before starting the large right turn into the maneuvering area. Acceptable docking postures can be achieved for both existing and proposed channel conditions under both ebb and flood tide so as to allow safe tanker docking into the Long Wharf. The containership tests indicate that it is reasonably safe to maneuver around the point and line up with the

Richmond Harbor entrance channel on flood tide. Ebb tide conditions require very careful control of ship speed and position to execute a safe turn in the maneuvering area when piloting the 810-ft containership. The 638-ft containership was much easier to maneuver around the point.

Jagniszczak, I. 1988. Region of the Odra Estuary and its connections with the hinterland. *Bulletin of the Permanent International Association of Navigation Congresses* 60:46-63.

The system and parameters of fairways of the Odra estuarian region have a direct effect on the volume of port transhipments, both in sea and in inland navigation. In the years 1945-1987 a considerable development of port infrastructure took place in the region. This is partly because the size of vessels in operation in the region of the Odra Estuary has increased. This is turn has brought about the need to enlarge the fairway parameters. The increased activity of small ports and the development of inland navigation in this region have been determining factors for deciding the layout of new fairways and the most adequate markings to ensure the safety of navigation. (5 refs)

Jarvis, R. M. 1985. Problems associated with the development of a partially open tidal estuary with particular reference to Currimundi Creek, Queensland. In *1985 Australasian Conference on Coastal and Ocean Engineering,* 2-6 December 1985, Christchurch, New Zealand, 1:581-590. Barton, A. C. T., Australia: The Institution of Engineers, Australia.

Currimudi Creek is typical of many small streams on the east coast of Australia in that it is closed off from the ocean for most of the year, owing to the formation of a sand berm across the mouth. It is perhaps unique in that it is subject to extensive canal development in the swampy country surrounding the creek and the adjacent Mooloolah River floodplain. Consequently some unique problems have arisen with respect to the extra tidal compartment, increased velocities with possible erosion of adjacent land, and loss of amenity due to the perceived lack of depth because of the creek remaining open to the tide for longer periods. (4 refs)

Johnson, B. H., Boyd, M. B., and Keulegan, G. H. 1987. A mathematical study of the impact on salinity intrusion of deepening the Lower Mississippi River navigation channel. (See complete entry in Section VI.)

Jones, E. R., and Hubbard, S. D. 1986. Maryland's phosphate ban--History and early results. *Journal Water Pollution Control Federation* 58(8):816-822.

On 28 May 1985, Governor Harry R. Hughes formally signed into law a bill that prohibits the sale of phosphate detergents in the State of Maryland. With its implementation on 1 December 1985, Maryland became the seventh state in the Nation to impose a statewide phosphate ban. This initiative, designed to help curb phosphorus overenrichment, was one of several aimed at reversing the decline of Maryland's single greatest resource--the Chesapeake Bay. This article presents the early results of the ban, cites the memorable events and turning points that paved the way for the ban, and briefly discusses what phosphorus overenrichment is and why it is a problem in the bay. (5 refs)

Kennedy, V. S., ed. 1984. *The estuary as a filter.* (See complete entry in Section VI.)

Lask, E. 1988. Rescue of Venice finally under way. *ENR* 221(21):28-30.

This article discusses an incident in which Venetians awoke November 4, 1966, to find their city flooded with the historic St. Mark's Square under 4 ft of water. A mechanism to prevent such rude awakenings has now been activated. It is called MOSE, an Italian acronym for experimental electromechanical module. It will test a gate that one day will form part of a system of three barriers to defend the city from periodic incursions of flood tides from the Adriatic Sea. The barriers are part of a program that includes structural and environmental restoration as well as pollution abatement in the lagoon surrounding the Venetian archipelago.

Liu, J. 1986. A study on the siltation in the approach channel with different alignments of the Lianyun Harbour. (See complete entry in Section VIII.)

Lloyd, P. J., and Cockburn, A. G. 1983. Pollution management and the tidal Thames. (See complete entry in Section IV.)

Lowery, T. A., ed. 1987. *Symposium on the natural resources of the Mobile Bay Estuary*, February 1987, Mobile, Alabama. Mobile, AL: Alabama Sea Grant Extension Service, Alabama Cooperative Extension Service, Auburn University.

This symposium provided a forum to present the results of studies management activities, and related information pertinent to improving communal

stewardship of the Mobile Bay Estuary. The papers presented dealt with the resources of Mobile Bay; fisheries research and management; benthic and wetland resources habitat preservation, restoration and mitigation; educational efforts; hydrography, circulation, water quality and pollutants. The primary objectives of this symposium were to bring this information together and to identify a new set of management/research recommendations.

McLaren, P., and Powys, R. 1989. The use of sediment trends to assess the fate of dredged material. (See complete entry in Section II.)

Matondo, J. I. 1989. Beach erosion protection methods: Case study of Dar City, Tanzania. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 242-247. New York: ASCE.

Beach erosion is caused by waves and currents. The waves are caused by wind and tide action. Moving ships and boats also generate waves. However, the ship- and boat-generated waves are effective in causing beach erosion if the ship or boat is moving near the shore line. This paper discusses a case study of beach erosion in Dar es Salaam along with beach erosion protection methods to minimize the phenomenon. Coastal Tanzania has been experiencing severe beach erosion. Beach erosion is much felt in coastal cities like Dar es Salaam, Tanga, etc. Beach erosion in Dar es Salaam has caused damage to property. Several beach erosion protection methods have been implemented in Dar es Salaam. The implemented beach erosion protection techniques are (a) groins, (b) riprap, (c) combination of groins and riprap, and (d) cement pipes and stumps. This paper presents an evaluation of the effectiveness of these beach erosion protection methods. Recommendations for other beach erosion protection methods are also presented. (6 refs)

Mehta, A. J. 1987. Hydraulics and stability of a small inlet. *Shore & Beach* 55(3/4):96-100.

Small sandy inlets offer a unique advantage over larger ones in relation to field data collection, which can be carried out with comparative ease at a small inlet. Since such inlets are subject to natural forces, they serve as nature's models. The principal objective of this study was to investigate the hydraulics and stability of a very small sandy inlet, in order to improve understanding of the physical processes at inlets in general. Although the investigation was of a preliminary nature, a significant conclusion was that more detailed studies can lead to extremely useful insight into the mechanics of the involved physical processes. The inlet in this study connected a small lagoon, also referred to as O'Brien's Lagoon, to the Gulf of Mexico, adjacent to John's Pass, a comparatively large inlet at the north end of Treasure Island, Florida. Tide in this area is mixed, with a periodic oscillation from semidiurnal to diurnal. There were no tributary inflows into the lagoon, and water salinity was fairly constant. (10 refs)

Middleton, M. J., Rimmer, M. A., and Williams, R. J. 1985. Structural flood mitigation works and estuarine management in New South Wales--Case study of the Macleay River. *Coastal Zone Management Journal* 13(1):1-23.

In many estuaries of New South Wales (N.S.W.), agricultural, urban, and industrial activities have benefitted at the expense of naturally occurring attributes such as commercial and amateur fisheries, wildlife habitats, recreational resources, and esthetic and cultural values. The successful future management of the estuarine environment is contingent on a number of factors, including a paucity of baseline data, a lack of predictive models, the difficulty of quantifying natural attributes, and a previous tendency to study the effects of each development proposal on an individual rather than on a cumulative basis. A positive step in estuarine management was recently taken by the N.S.W. government with the passage of legislation whereby environmental considerations are incorporated into planning and management procedures. However, shortcomings still exist in the overall management approach. This paper illustrates some of these shortcomings by examining the adverse environmental effects of structural flood mitigation works on the Macleay River Estuary. Desirable considerations for the future management of estuaries are discussed. Particular emphasis is placed on the need for environmental compensation and habitat restoration, two concepts which, until recently, have had restricted application in coastal management in New South Wales. (35 refs)

Miles, G. V., and Cooper, A. J. 1985. Application of a DAP computer to tidal problems. (See complete entry in Section VI.)

Nelissen, H. A. M. 1986. Foundation of the Eastern Scheldt storm surge barrier. *LGM-Mededelingen* 94:2-39.

The geotechnical aspects which have played a part in

the development of the design of the barrier are discussed briefly and emphasis is given to specific geotechnical construction aspects. Topic contents include Part I: History and design; (a) Physical conditions in the Eastern Scheldt Estuary; (b) The general design philosophy for the barrier; (c) Various alternatives for a storm surge barrier; (d) The geotechnical aspects of the barrier; (e) Criteria for the foundation base. Part II: The construction of the storm surge barrier; (a) Soil improvement (3 refs); (b) Compaction of the foundation (10 refs); (c) Pier installation (9 refs); (d) Vibrator plate densification (11 refs); (e) Abutment foundation (3 refs); (f) Negative overlap (3 refs); (g) Erosion at the edges of the seabed protection (5 refs); (h) Monitoring the barrier (4 refs).

Oyegoke, E. S., Osoba, E. B., Oladapo, O. O., Uzochukwu, B. N., and Ibrahim, A. 1983. Coastal erosion problems in Nigeria and some measures adopted over the years for their solution. In *International conference on coastal and port engineering in developing countries,* 20-26 March 1983, Colombo, Sri Lanka, I:141-147. Colombo, Sri Lanka: Conventions (Colombo) Ltd.

This paper discusses the coastal erosion problems in Nigeria, the prevailing longshore drift processes, and natural and artificial factors which affect the sand transport. It considers coastal erosion in storms, estuarine erosion, siltation, and saline intrusion, and notes protection measures taken. Beach erosion and accretion around Lagos are described in detail. (4 refs)

Pilarczyk, K. W., Misdorp, R., Leewis, R. J., and Wisser, J. 1986. Strategy to erosion control of Dutch estuaries. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:963-983. University, MS: University of Mississippi.

The general management strategy to erosion control of Dutch estuaries is outlined. Various methods of shore protection (offshore breakwater, shore protection, and floating structures) in different types of (former) estuaries (salt and fresh water, tidal and fixed level) are discussed. Examples from schemes already realized are given. Attempts to control erosion in the future Eastern Scheldt basin and the necessary research are discussed. Special attention is paid to environment-friendly solutions and the choice of the proper constructions. (29 refs)

Ports, M. A., ed. 1989. *Hydraulic engineering*. (See complete entry in Section I.)

Raney, D. C., and Youngblood, J. N. 1987. Numerical modelling of salinity propagation in Mobile Bay. (See complete entry in Section VI.)

Reinson, G. E. 1977. Tidal-current control of submarine morphology at the mouth of the Miramichi Estuary, New Brunswick. (See complete entry in Section I.)

Richards, D. R., and Clausner, J. E. 1988. Feasibility of sand bypassing systems for reducing maintenance dredging in the St. Marys River entrance channel. Miscellaneous Paper HL-88-9. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

This report provides a sand bypassing feasibility analysis for the St. Mary's River entrance channel. The study was conducted in connection with the development of the US Navy's Trident submarine base in King's Bay, GA. The analysis found that sand bypassing would not provide a significant reduction in the total amount of maintenance dredging required in the entrance channel, but could provide for a cost-effective means of dredging disposal and beach nourishment. (7 refs)

Saeijs, H. L. F. 1987. Towards control of an estuary. *Water Science and Technology* 19(9):155-174.

The Delta Project is in its final stage. In 1974 it was subject to political reconsideration, but it is scheduled now for completion in 1987. The final touches are being put to the storm-surge barrier and two compartment dams that divide the Oosterschelde into three areas: one tidal, one with reduced tide, and one a freshwater lake. Compartmentalization will result in 13 percent of channels, 45 percent of intertidal flats, and 59 percent of salt marshes being lost. There is a net gain of 7 percent of shallow-water areas. Human interventions with large-scale impacts are not new in the Oosterschelde but the large scale and short time in which these interventions are taking place are, as is the creation of a controlled tidal system. This article focusses on the area with reduced tide and compares present-day and expected characteristics. In this reduced tidal part salt marshes will extend by 30-70 percent; intertidal flats will erode to a lower level and at their edges; and the area of shallow water will increase by 47 percent. Biomass production on the intertidal flats will

decrease, with consequences for crustaceans, fishes, and birds. The maximum number of waders counted on 1 day and the number of "bird-days" will decrease drastically, with negative effects for the wader populations of western Europe. The net area with a hard substratum in the reduced tidal part has more than doubled. Channels will become shallower. Detritus import will not change significantly. Stratification and oxygen depletion will be rare and local. The operation of the storm-surge barrier and the closure strategy chosen are very important for the ecosystem. Two optional closure strategies can be followed without any additional environmental consequences. It was essential to determine a clearly defined plan of action for the whole area, and to make land-use choices from the outset. How this was done is briefly described. (25 refs)

Salomons, W., Schwedhelm, E., Schoer, J., and Knauth, H. 1988. Natural tracers to determine the origin of sediments and suspended matter from the Elbe Estuary. (See complete entry in Section II.)

Saxena, P. C. 1983. Effects of reclamation of inter tidal zones in the Mahim Creek. In *International conference on coastal and port engineering in developing countries,* 20-26 March 1983, Colombo, Sri Lanka, II:1483-1494. Colombo, Sri Lanka: Conventions (Colombo) Ltd.

The Mahim Creek, about 13 km long located in the southwestern part of Bombay Island, is influenced by tidal action and serves as a drainage channel during the southwest monsoon period. The water spread area of the creek is being progressively reduced through periodic reclamation with the result that not only the adjacent areas get flooded but also pollution level of the creek waters increases. Future reclamation is also being planned. In order to examine the problem in its entirety hydraulic model studies were undertaken at the Central Water and Power Research Station, Pune. Remedial measures such as channelization by widening and deepening of the existing channel, lowering of the natural rock sill at the Mahim Creek, and providing a gate to prevent tidal influx during monsoon were studied; and optimum reclamation possible was arrived at. This paper discusses the improvements in the hydraulic and environmental conditions that could be achieved with the channelization program and the optimum reclamation possible.

Schmalz, R. A., Jr. 1985. Numerical model investigation of Mississippi Sound and adjacent areas. (See complete entry in Section VI.)

Schmalz, R. A., Jr. 1986. Sediment transport management in the Columbia River entrance. (See complete entry in Section II.)

Seabergh, W. C. 1976. Improvements for Masonboro Inlet, North Carolina. Technical Report H-76-4, Vol I and II. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Masonboro Inlet, located at the southern end of the important resort area of Wrightsville Beach, is a natural channel through the coastal barrier beach of North Carolina that conducts tidal flows between the Atlantic Ocean and a channelized lagoon. The inlet provides passage from the ocean to the Atlantic Intracoastal Waterways and to various private and commercial docking. Improvements for the inlet were authorized in 1949 and included two jetties, an ocean entrance channel between the jetties, and interior bay navigation channels. Initially, the ocean entrance channel was dredged to authorized dimensions of 14 ft deep by 400 ft wide through the ocean bar. Shoaling of this channel occurred, and in 1965 construction of the north jetty on the apparent updrift side of the inlet began. This 3,600-ft-long jetty had a 1,000-ft-long weir at an elevation of 0 ft msl at its shoreward end. A deposition basin on the lee side of the weir was dredged to contain the sediments passing over the weir; the entrance channel was reestablished. After construction, the plan functioned well for a year and a half with the deposition basin filling. However, the entrance channel migrated toward the north jetty structure and cut through the deposition basin in the following years, jeopardizing the structural integrity of both the concrete sheet pile weir and the rock rubble portion of the jetty. To aid in alleviating these problems, the Wilmington District submitted plans to the South Atlantic Division for construction of a south jetty. The preconstruction planning and design required hydraulic model testing to aid in determining such design parameters as minimum required jetty length, alignment, spacing, proper channel alignment, entrance current patterns, and currents occurring during construction. The Masonboro Inlet fixed-bed model was constructed of concrete to scales of 1:300 horizontally and 1:60 vertically. The model reproduced an area extending to the -45 ft contour in the Atlantic Ocean and to the extent of the influence of the inlet in the bay. The wetlands were accurately reproduced near the inlet, but those relatively flat areas farther bayward were reproduced schematically and artificially bent into the research flume to provide storage for the tidal prism. Model verification tests assured that the model hydraulic and shoaling regimes were in satisfactory

agreement with the prototype. Preliminary testing included the examination of tidal surface current patterns for various structural configurations, including training structures to deflect currents away from the north jetty, offshore breakwaters, and various south jetty alignments. Plan B of the District was selected as the best design and was subjected to detailed testing. This testing indicated that construction of the plan B south jetty would aid in maintaining a channel more centrally located between the jetties, away from the north jetty. The construction of a deposition basin in Banks Channel near the entrance of the inlet was also investigated. It was found that the basin produced velocity increases along the Wrightsville Beach shoulder of the inlet. (4 refs)

Seabergh, W. C. 1985. Los Angeles and Long Beach Harbors model study; Deep-draft dry bulk export terminal, alternative No. 6: Resonant response and tidal circulation studies. (See complete entry in Section I.)

Sheng, Y. P., and Butler, H. L. 1982. A three-dimensional numerical model of coastal, estuarine, and lake currents. (See complete entry in Section VI.)

Smith, T. M. 1986. Corpus Christi inner harbor shoaling investigation. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:984-990. University, MS: University of Mississippi.

Corpus Christi Harbor, located at the northwestern corner of Corpus Christi Bay, experiences repetitive high shoaling rates in the harbor entrance area. A planned deepening project for the harbor is expected to increase shoaling rates and volumes. The sedimentation processes which occur in the harbor are numerically simulated to evaluate plans for the reduction of harbor shoaling. The vertically averaged numerical modeling system, TABS-2, is used to simulate contributions of sediments by bay waters to the sediment load. The laterally averaged estuarine model, LAEMSED, is used to simulate density currents in the channel and sedimentation that occurs at the harbor entrance. The two models are paired to provide meaningful and quantitative results of a study of alternatives to reduce maintenance dredging costs at Corpus Christi Harbor. This paper focuses on the models and their combined effectiveness in simulating sedimentation processes in the harbor and in evaluating the planned alternatives. (3 refs)

Sorensen, R. M. 1989. Stability analysis of the three inlets to Venice Lagoon, Italy. *Shore & Beach* 57(3):26-30.

The city of Venice, Italy, is built on a cluster of islands inside Venice Lagoon. The lagoon is separated from the Adriatic Sea by a barrier beach which is cut by three inlets—Bocca di Lido, Bocca di Malamocco, and Bocca di Chioggia. Owing to compacting of lagoon sediments, Venicen is slowly sinking. This, coupled with rising sea levels, has increased the relative frequency of flooding of the city streets and plaza during winter storms. The Government of Italy is currently developing the designs for temporary closure works for the three inlets. These designs include submerged movable gates that can be raised during the brief periods of storm surge to prevent high water levels at Venice. In addition to providing for tidal exchange to prevent further deterioration of water quality in the lagoon, each of the three inlets supports a high level of vessel traffic to the industrial and fishing ports in the lagoon. Consequently, the closure works at the three inlets will also have navigation locks that will be used during periods of gate closure. Several possible design solutions have been developed for each inlet. The process of evaluating each of these possible solutions involved consideration of several factors including the potential for increased sediment erosion or deposition at the inlets. The author was a consultant to the engineering firm carrying out the evaluation of the various proposed solutions. His two tasks were to evaluate the historic and present stability conditions at the three inlets, and then to evaluate the potential for shoaling or erosion for the proposed control works solutions. This paper reviews the work done for the first task. (9 refs)

Teeter, A. M., and Pankow, W. 1989. Deposition and erosion testing on the composite dredged material sediment sample from New Bedford Harbor, Massachusetts. (See complete entry in Section II.)

†**The Thames has come alive again.** 1980. *Environmental Pollution Management* 10(4):111-112.

In the early 1950's some 25 miles of the Thames River was heavily polluted. Now, it is probably the cleanest metropolitan estuary in the world. Improvements included construction of secondary treatment and activated sludge plants, among them Long

Reach, which had been the site of sewage treatment activities since 1877. Despite initial work conducted in 1960, it was not until 1970 that approval was granted for the construction of major improvements, including biological treatment. Treatment processes initiated in 1972 included four new primary sedimentation tanks, a powerhouse, and generating equipment. In 1973, work included eight final settling tanks, a compressor house, and two return activated sludge pumping stations. At Long Reach, sewage passes through screening and grit removal, primary sedimentation, aeration, and final sedimentation. Some 85 percent of the power needed is produced by dual-fed generators using CH_4 produced in the digestion plant. Although Long Reach currently treats, on an average, some 40 mgd, the extensions have a designed maximum capacity of 88 mgd, sufficient for the foreseeable future.

Thomas, W. A., and McAnally, W. H., Jr. 1985. User's manual for the generalized computer program system: open-channel flow and sedimentation, TABS-2; main text. (See complete entry in Section VI.)

Thorn, D. B., and Guganesharajah. 1986. Flood protection and drainage of the East and West Fens unsteady flow modelling studies. (See complete entry in Section VI.)

Tidal gate capsizes salinity control job. 1987. *ENR* 219(10):13-14.

Red-faced engineers are hurrying to find a quick solution after a 6,000-ton tidal control gate tipped over while being sunk into place last week in the Montezuma Slough in the Sacramento River Delta. A part of the 120- by 87-ft concrete structure lodged on the bottom about 10 ft off its intended position in the 44-ft-deep channel near Fairfield, CA. Tod Santos, chief of construction for the California Department of Water Resources, says it appears the rigging used to keep the top-heavy structure upright as it was being sunk into position simply wasn't strong enough to control the sway. The rigging included cables from shore and a sling suspended from a 350-ton floating crane. The contractor, a joint venture of Morrison Knudsen Company, Inc., Boise, ID, and Dutra Construction Company, Rio Vista, CA., refused comment on the incident. The structure which tipped over includes three 35-ft-wide, 30-ft-high radial gates, joined to a 19-ft-high submersible raft, all made from lightweight concrete. The raft has 30 separate ballast compartments. The structure was assembled in Stockton and Rio Vista and brought to the job site on barges. According to Santos, the main safety concern in the sinking operation was to control pressure differentials between the compartments to prevent bursting. With its center of gravity "several feet" above its buoyancy point, it was clear the structure would be unstable when partially submerged, says Santos. But when some roll developed, the rigging could not control the operation. No one was hurt in the incident. The water resource department immediately demanded that Dutra/MK come up with a definite plan by 1 September for fixing the problem and that the structure be correctly in place by the end of September. Santos says the speed is needed so the entire $13-million tidal and salinity control project can be completed before the winter rain and flood season begins. Work in the Delta area becomes more difficult at that time. The job was to be finished by 23 November. Besides the tidal gate, a prefabricated lock for pleasure boats and a flashboard structure for larger barge traffic must be put in place across the 400-ft-wide channel. But the other components cannot be positioned until the central tidal gate is in its proper place.

Toorman, E. A., and Berlamont, J. E. 1989. Estuarine mud flow modeling. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 230-235. New York: ASCE.

This paper presents a model for the simulation of selective withdrawal of estuarine mud. This research is part of the investigation of the design of a mud pumping plant as an alternative for dredging. The problems confronted are the non-Newtonian behavior of mud and the water-mud interface modelling. The change of the interface shape requires the problem to be solved time-dependently. A finite element method is used. (5 refs)

van Rijn, L. C. 1986. Sedimentation of dredged channels by currents and waves. (See complete entry in Section VI.)

Vemulakonda, S. R., Swain, A., Houston, J. R., Farrar, P. D., Chou, L. W., and Ebersole, B. A. 1985. Coastal and inlet processes numerical modeling system for Oregon Inlet, North Carolina. (See complete entry in Section VI.)

Vittor, B. A., Stewart, J. R., Jr., and Middleton, A. L. 1987. Creation of a brackish tidal marsh at West Fowl River, Alabama. In *Symposium on the*

natural resources of the Mobile Bay Estuary, February 1987, Mobile, Alabama, 120-129. Mobile, AL: Alabama Sea Grant Extension Service, Alabama Cooperative Extension Service, Auburn University.

A 40-acre brackish marsh is being created near West Fowl River for North American Gulf Terminals, Inc., as a condition of the Corps of Engineers permit for construction of a coal/grain facility at Theodore. The mitigation site was selected for its low elevation (+1.3 m MSL) and access to tidal recharge via an existing canal network. It contains a *Juncus roemerianus-Phragmites communis* zone near the river and the *Pinus elliotti* zone which is being excavated. An average of 1 m of topsoil and sandy clay has been removed by dragline, in order to attain a finished elevation of +0.3 m MSL. Four tidal canals allow an adequate flow of brackish water into the site during flood tide. Excavated material forms mounds which will eventually provide upland habitat in the midst of the new wetland. A lower zone (+0.15 m) is being created along the waterways to improve the quality of new *Spartina alterniflora* marsh to be planted. The site becomes fully flooded during high tide and flushes very quickly during ebb tide. (10 refs)

Vongvisessomjai, S., and Pongpirodom, P. 1986. A laterally averaged model for estuarine sedimentation. (See complete entry in Section VI.)

Wang, J. D., and van de Kreeke, J. 1986. Tidal circulation in North Biscayne Bay. (See complete entry in Section VI.)

Wang, S. Y., Shen, H. W., and Ding, L. Z., eds. 1986. *River Sedimentation.* (See complete entry in Section II.)

Ward, G. H. 1989. Of Matagorda Bay: Access may be a key to future productivity. *Watermarks* 25(4):5,7.

This is a brief article which discusses the alterations that have been underway in Matagorda Bay. These involve the inlets of the system and the passages through the barrier island connecting the bay with the sea, and have the potential to affect the fishery of the bay. At present, the first phase of the Corps of Engineers Colorado River diversion project is in completion, with the objective of returning the flow of the Colorado into Matagorda Bay by dredging a new channel for the river into the bay's east arm. The old channel will be dammed off, and Parkers Cut closed. This project will eliminate the Colorado Mouth-Parkers cut inlet to the system. If Pass Cavallo goes also, only the entrance channel will remain as the sole inlet to the bay. Then the productivity of the bay may be limited, not by nutrient loading or salinity regime or habit, but by the most fundamental parameter of all: access.

Weishar, L. L., and Aubrey, D. G. 1988. Inlet hydraulics at Green Harbor, Marshfield, Massachusetts. Miscellaneous Paper CERC-88-10. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

A combination office study, field data collection, and numerical model study was used to determine the principal causes of shoaling at Green Harbor, MA. Results of a yearlong data collection effort which obtained directional wave information offshore of the harbor entrance revealed that the harbor is subjected to waves of over 12-sec periods. Results of the wave refraction study and sediment transport calculation formed the basis of the sediment budget which identified the major sediment sources for each of the shoals within the tidal inlet system. The conclusion of the study recommends several methods for decreasing the dredge return frequency at Green Harbor. (20 refs)

Weishar, L. L., and Fields, M. L. 1985. Annotated bibliography of sediment transport occurring over ebb-tidal deltas. (See complete entry in Section II.)

Wood, B. R., and Netchael, P. 1985. Hydraulic & sediment transport investigation for a coal port at Batam Island, Indonesia. In *1985 Australasian conference on coastal and ocean engineering,* 2-6 December 1985, Christchurch, New Zealand, 2:401-411. Barton, A. C. T., Australia: The Institution of Engineers, Australia.

The hydraulic and hydrodynamic investigations for a major coal port on Batam Island, Indonesia, are described. Wave climate, current and tidal regime, and sediment transport were considered, all of which have substantial impacts on matters such as (a) size of ships, (b) ability to navigate and berth ships, (c) dredging requirements, and (d) conceptual design of the port and infrastructures. Progress of the technical investigations is presented starting with the Prefeasibility Stage with its limited data, the subsequent Feasibility Stage through to the present completed stage of Preliminary Engineering. At any of these stages the technical assessment forms an essential part in determining the overall economics

and hence continued viability of the proposed development. By comparing the technical estimates and assumptions for the three completed stages it is evident that the initial perception of technical problems may not always hold true in the long term. However, an early appreciation of the true nature of a problem is often difficult to achieve without more detailed investigations which, of course, negates the purpose of Prefeasibility and Feasibility stages. It is important that both Consultant and Client appreciate this "Catch 22" situation. (6 refs)

Wright, D. A., and Phillips, D. J. H. 1988. Chesapeake and San Francisco bays: A study in contrasts and parallels. (See complete entry in Section IV.)

SECTION VI. MODELING AND OTHER LABORATORY EXPERIMENTS

Physical and mathematical model studies and other controlled experiments connected with any phase of tidal hydraulics. Investigations of theoretical aspects, studies for improvement or regulation at specific localities, theory of physical model design and operation, physical model appurtenances, and types of problems susceptible of model analysis.

Aamodt, T., and Dahl, R. 1984. Modelling of tidal rivers. In *Proceedings of the Fourth Congress of Asian and Pacific Regional Division of the International Association for Hydraulic Research,* 11-13 September 1984, Chiang Mai, Thailand, I:481-495. Bangkok, Thailand: International Association for Hydraulic Research, Asian and Pacific Division.

The flow in the tidal part of a river is influenced both by the tidal motion and the upland discharge. The velocity varies continuously and the direction may even be reversed; hence the flow is never in a steady state. Numerical modelling is widely used when investigating long river reaches, while physical models may yield useful information when studying local phenomena. The present paper deals with the two more recent (laboratory) model investigations regarding tidal rivers, in which our laboratory has been involved. Both studies deal with rivers in Bangladesh. The field measurements, model instrumentation, and flow control equipment are described in detail, and also the method applied. (3 refs)

†**Aiyesimoju, K. O.** 1986. Numerical prediction of transient water quality in estuarine/river networks. Ph.D. diss., University of California, Berkeley.

This dissertation is concerned with the numerical prediction of transient water quality in estuarine/river networks and involves the numerical solution of the hydrodynamics equations and the mass transport equations. The impact of longitudinal density gradient on estuarine hydrodynamics is first investigated. This necessitated the derivation of the one-dimensional wide-channel hydrodynamics equations in the presence of longitudinal density gradients. It is shown that longitudinal density gradients could have a significant impact on estuarine hydrodynamics in extreme cases, but the impact is typically negligible. Solution of the hydrodynamics equations could thus be justifiably decoupled from the mass transport equations and the hydrodynamics so resulting then used in solving the mass transport equations. Solution of the hydrodynamics equations can now be classified as routine if there is adequate grid resolution. The solution of the mass transport equations has however met with more difficulties, the fundamental problem being numerical approximation of the advective terms in the equations. Based on the fractional step method, Sobey developed a successful solution of the advection-dispension-reaction equation in a single channel and for one constituent with linear reaction kinetics. This is extended to multiple constituents interacting in a complex, even nonlinear manner and for an arbitrarily interconnected network of channels. A major inconvenience of the fractional step method lies in the treatment of the boundary conditions. The given boundary conditions correspond to the complete equation and not to any of the split equations used in the intermediate fractional steps. This problem is investigated and appropriate techniques to accommodate it developed and evaluated. The recommended approach is then incorporated into the numerical solution developed. Finally, the use of the numerical model as a practical water quality management tool is demonstrated by simulating the effects of waste discharge strategy and outfall location on the dissolved oxygen levels in La Paz lagoon in Baja California, Mexico. If hydrodynamics equations can be decoupled from the mass transport equations, the model is equally applicable to the simulation of transient water quality in any network of one-dimensional channels (e.g., pipeline and sewer networks).

Allen, J. R. L. 1982. Simple models for the shape and symmetry of tidal sand waves: (3) Dynamically stable asymmetrical equilibrium forms without flow separation. *Marine Geology* 48(34):321-336.

The complex interaction between the local steepness of a sand bed and the tidally induced bed-load transport over it is theoretically such that dynamically stable sand waves of asymmetrical cross-section can exist beneath a tidal current in which one stream (dominant) exceeds in peak speed the other (subordinate). Calculations based on a mathematical model embodying these effects show that, as with naturally occurring sand waves, the degree of sand-wave morphological asymmetry increases with growing hydraulic asymmetry, it being supposed as a compromise and for simplicity that the streams are of equal duration and simple-harmonic in variation but of different peak speeds. The calculated sand waves are translators and their steeper side faces in the direction of the dominant tidal stream and the net bed-load transport, as would appear to be the case for naturally occurring forms. However, the precise form of the increase of morphological asymmetry with hydraulic asymmetry, together with the bounds on the existence field for sand waves, is influenced by the magnitude of the bed-material entrainment threshold relative to the peak speeds of the tidal streams. The main limitations on the model are its severely simplified treatment of flow and bed-load transport over sand waves, and the lack of empirical data by which to test the proposed bed-steepness effects. (26 refs)

Apelt, C. J. 1980. A decade of hydraulics in Australasia. (See complete entry in Section I.)

Ashley, G. M., and Grizzle, R. E. 1988. Interactions between hydrodynamics, benthos and sedimentation in a tide-dominated coastal lagoon. (See complete entry in Section II.)

Baillie, P. W. 1986. Oxygenation of intertidal estuarine sediments by benthic microalgal photosynthesis. *Estuarine, Coastal and Shelf Science* 22(2):143-159.

A mathematical model was used to define the relative importance of microalgal photosynthesis and physical processes in the formation and maintenance of the oxygenated zone on the surface of intertidal estuarine sediments. Manometric measurements of sediment uptake and release showed that gross oxygen production usually exceeded aerobic community respiration. Polarometric microprobes measured vertical oxygen distributions in the sediment. Surface levels of oxygen ranged from 200 percent saturation in summer to 70 percent in winter. Profiles and flux measurements allowed calculation of sediment diffusion coefficients. Empirical evaluation of the terms of the model showed that epipelic diatom photosynthesis as a source of oxygen at low tide may exceed atmospheric diffusion by an order of magnitude. On a diurnal and seasonal basis, however, the diatoms may be less important to the oxygenation process than the physical forces of the tide. (30 refs)

Baines, P. G. 1983. Tidal motion in submarine canyons—A laboratory experiment. *Journal of physical oceanography* 13(2):310-328.

The reasons for the large-amplitude tidal motion observed n oceanic submarine canyons have been explored with a laboratory experiment. A barotropic tide was forced in a stratified tank, containing continental shelf-slope topography into which a narrow canyon was incised. Large-amplitude tidal motions were observed in the canyon; it is shown that these were forced by the large horizontal pressure gradient existing on the continental shelf near the canyon head. Another significant feature of this experiment was that internal waves inside the canyon were partially reflected from the open boundary at the mouth of the canyon, like sound waves from the open end of an organ pipe. This enabled energy to propagate down the canyon in the form of leaky modes. The character of the flow in the canyon was strongly dependent on the ratio of bottom slope α to ray (or characteristic) slope c. For $\alpha/c \ll 1$ the stratification had little effect on the motion, and the largest displacements were nearly barotropic and occurred near the canyon head; for $\alpha/c \approx 1$ the motion was baroclinic and had the same pattern at all depths. For $\alpha/c > 1$ the energy propagated down the canyon in the form of leaky modes; because of reflection at the bottom, large amplitudes may occur near there in some cases. The analysis also suggests a mechanism for the large amplitudes of high-frequency internal waves observed in submarine canyons. For a narrow canyon, wave motion in the canyon will be forced at the mouth by the pressure field of an incident wave from the deep sea, plus that of the wave reflected from the external continental slope; this will result in a wave with up to twice the amplitude (and hence four times the energy) inside the canyon. (9 refs)

Baker, T. F., Edge, R. J., and Jeffries, G. 1982. High precision tidal gravity; Final report, 1 April 1980-31 March 1982. (See complete entry in Section VII.)

†Bales, J. D. 1986. Field and numerical studies of tracer gas transport and surface gas transfer in laterally uniform, partially stratified estuaries. Ph.D. diss., The University of Texas at Austin.

Techniques for determination of reaeration rates in natural water bodies are reviewed. The tracer gas technique for reaeration rate determination offers many advantages over other existing methods and is widely used in rivers and streams. The tracer gas method seems to be the most promising of available techniques for estuarine reaeration rate determination. The two-dimensional late-rally averaged equations describing flow and transport in estuaries are derived and discussed. A laterally averaged numerical model of estuarine hydrodynamics and transport is modified so that tracer gas releases may be simulated. Modifications include application of the fractional step technique and a sophisticated interpolation scheme to reduce numerical dispersion, implementation of a variable vertical grid, and inclusion of a surface exchange algorithm. Procedures are outlined for two-step application of the model to long reaches so that longitudinal discretization of the reach may be coarse except near the tracer gas cloud. The model is applied to a hypothetical estuary (and to an actual estuary as summarized below) to test tracer gas field and data analysis procedures. Three methods of analyzing the surface transfer rate are evaluated--a method based on using the numerical model and field data to fit a transfer coefficient to the data, a method based on the temporal rate of mass change, and an

analytical solution. Field studies conducted as a part of the study are described. Two dye releases were made in the upper Houston Ship Channel; two dye and tracer gas releases were later made in the same region. The data from these studies are presented and analyzed. Mechanical mixing by shipping traffic proved to be the predominant mixing mechanism and a hindrance to further studies at that site. An intensive field study was conducted in the Colorado River Estuary. Field data included velocities, salinity profiles, water surface elevations, and dye concentration data from three dye releases. The data from this study are used to calibrate and test the numerical model of estuarine tracer gas transport. An instantaneous and a continuous release of tracer gas are simulated, and the surface transfer rate coefficient is calculated from simulated data. Procedures for implementing the technique in estuaries are discussed relative to data analysis procedures.

†**Balls, M.** 1988. The optimal selection of turbine-generators for tidal power projects and the optimization of their operation. Ph.D. diss., University of Salford (United Kingdom).

This dissertation describes the development of a suite of computer programs designed to evaluate the optimum operating strategy for turbine-generators installed in a proposed tidal power barrage. The computer models are of the single-tide type but have been extended to incorporate detailed models of the turbine performance characteristics and operating constraints. The computer programs have been extensively used for studies of the Severn and Mersey barrage proposals in the United Kingdom, for one of the proposed barrage schemes in the Bay of Fundy, Canada, and for the now-operating scheme at Annapolis Royal, Canada. One of the most important features of these programs is their ability to simulate, using appropriate characteristics, all the different turbine types suitable for tidal power generation. Results are presented of particular studies showing in each case the conclusions reached.

Bedford, K. W. 1985. Selection of turbulence and mixing parameterizations for estuary water quality models. Miscellaneous Paper EL-85-2. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Recognizing the interdependence between turbulence closure models required for an estuary transport model and the physics to be resolved in the model, this report summarizes considerations in the selection of the turbulence model. A review of various types of estuaries and their origins is followed by a description of commonly accepted physical transport mechanisms in estuaries. Recent research on estuaries is summarized. Following a synthesis of estuary time-space variability, averaging methods for deriving estuary transport models consistent with this variability are generalized. The equations for one-dimensional, two-dimensional (vertical and horizontal), and three-dimensional models are presented with particular attention paid to the terms requiring closure. Turbulence models are reviewed in the context of a hierarchical approach with commonly used functional forms and coefficient values tabularized. Finally, selection guidelines for the various closure forms are summarized. (160 refs)

Berger, R. C., Jr., Heltzel, S. B., Athow, R. F., Jr., Richards, D. R., and Trawle, M. J. 1985. Norfolk Harbor and channels deepening study: Report 2, Sedimentation investigation; Chesapeake Bay hydraulic model investigation. (See complete entry in Section II.)

†**Berger, T. J.** 1987. A simple numerical model for the study of baroclinic estuarine shelf interactions. Ph.D. diss., Old Dominion University, Norfolk, VA.

A one-and-a-half-layer nonlinear f-plane numerical model was used to study estuarine-shelf interactions. The single active layer covered a domain consisting of a 100-km-long by 20-km-wide channel discharging onto a 100-km-wide by 300-km-long shelf. Channel and "western" shelf boundaries were no-slip, "eastern" or oceanic boundary was free-slip and "northern" and "southern" shelf boundaries were open. The channel was forced with a constant inflow velocity spun up from 2 cm s^{-1} to 27 cm s^{-1} over 5 days. The model initial conditions were a flat interface at 10 m and zero velocity except at the inflow. Effects of varying interfacial friction, Newtonian cooling (vertical mixing of density or detrainment), channel configuration and wind stress were examined. The principal result was to show that Newtonian cooling rather than interfacial friction played a key role in deceleration and stagnation of an intrusion on the shelf relative to the constant phase speed in the channel. Deceleration of the density intrusion along the shelf coast agreed with results of three-dimensional numerical models, some laboratory models and with certain observed features of the Chesapeake Bay plume, for example. Results of a three-dimensional model were qualitatively reproduced as were features of a model which explicitly allowed the density interface to surface; that is, the plume flow was anticyclonic and marked by a region

of supercritical flow along its outer edge. There was an abrupt transition, marked by strong nonlinear dynamics, from the plume to a costal jet. Effects of channel configuration agreed with results of other models. Effects of wind stress were not adequately modeled probably due to failure to resolve the Ekman layer.

Bernshtein, L. B. 1988. From experimental to large tidal power stations (20th anniversary of the Kislogubsk tidal power station). *Hydrotechnical Construction* 22(12):687-692.

Thirty years ago the journal *Gidrotekhnicheskoe Stroitel'stvo* published suggestions on a new model of utilizing tidal energy and floated-in construction of a tidal power station (TPS). In 1968 these suggestions were realized in the creation of the Kislogubsk TPS, and subsequently were used in the designs of large TPS's planned for construction in a number of countries. The essence of this new model is that unlike the small multibasin plants proposed, it was suggested to utilize the tidal energy in single-basin stations of two-way action cutting off large marine bays. In large power systems it was possible to realize a valuable quality of tidal energy, consisting in the constancy of its mean monthly value regardless of the wetness of the season and year, concealed under the superficial cover of fluctuations in the monthly cycle and discontinuity in the diurnal period. A tidal power station using the single-basin scheme of two-way action is a source of ecologically clean energy, since it does not introduce changes into the natural regime of fluctuation of the basin. (14 refs)

Bhogal, V. K. 1989. A sediments dynamics model for flood tidal delta evolution. *Marine Technology Society Journal* 23(1):37-43.

Microtidal inlets are characterized by a large flood tidal delta, with a small or absent ebb tidal delta. Tidal inlet hydrodynamics indicate ebb dominant sediment transport. Sediment transport simulation was developed to resolve this conflict. Sebastian Inlet on the east coast of Florida was used as a prototype to test the simulation. This inlet has a small ebb tidal shoal configuration in sharp contrast to a dramatically growing flood tidal delta. A hydrodynamic and sand transport simulation model was developed to understand the processes that control the evolution of flood tidal deltas. The model assumes a gradually varying steady flow through the inlet. Velocities in the lagoon area, shoreward of the inlet throat, are based on continuity and a circular spreading front. Pertinent geometric features are allowed to vary with time. The results of the simulation describe many of the gross features of this particular type of inlet. The model predicts a non-shoaling inlet that allows some material to traverse the throat and enter the lagoon in a single tidal cycle. Within the inshore section the transport becomes flood dominant, reflecting the growth of a flood tidal delta. Even with greatly oversimplified hydraulic and geometric constraints the details of grain size distributions and growth rates of the delta appear to be reasonably consistent with observations. (7 refs)

Biggs, R. B., and Howell, B. A. 1984. The Estuary as a sediment trap: Alternate approaches to estimating its filtering efficiency. (See complete entry in Section II.)

Birch, P. B., Forbes, G. G., and Schofield, N. J. 1986. Monitoring effects of catchment management practices on phosphorus loads into the eutrophic Peel-Harvey Estuary, western Australia. (See complete entry in Section IV.)

Biswas, A. N., and Bandyopadhyay, K. K. 1987. Scour at Haldia oil jetty on the Hugli Estuary. (See complete entry in Section II.)

Blaauw, H. G., Lindenberg, J., Strating, J., and Vellinga, P. 1983. Numerical models in port design. In *International conference on coastal and port engineering in developing countries,* 20-26 March 1983, Colombo, Sri Lanka, I:552-569. Colombo, Sri Lanka: Conventions (Colombo) Ltd.

This paper reviews applications of numerical models to port development and planning. It discusses modelling of boundary conditions for waves and mentions frequency domain models and moored ship motions. This paper notes the use of finite element techniques and turbulent flow models for currents and flows in estuaries, navigation channels, or coastal seas. It discusses modelling and calculation of depth, width, and siltation of access channels and studies port layout requirement, e.g., ship maneuvering, wave forces, ship motions, sedimentation, and longshore sand transport effects. Modelling of breakwaters and structures within harbors is examined. (35 refs)

†**Blaha, G.** 1984. First- and second-phase gravity field solutions based on satellite altimetry. (See complete entry in Section VII.)

Bliek, A. J., Klatter, H. E., Konter, J. L. M., and van der Meulen, T. 1986. Short cut channels

in tidal estuaries. (See complete entry in Section V.)

Blumberg, A. F. 1978. The influence of density variations on estuarine tides and circulations. *Estuarine and Coastal Marine Science* 6(2):209-215.

Numerical experiments are carried out to investigate the influence of density variations on estuarine tides and circulations. The mathematical model, which has been previously published, is outlined. A detailed analysis of the tidal properties and circulations in an estuary is made for two cases. One case involved density variations while the other assumed a constant density. It was found that the discharge through any section, the tidal range, and the tidal phases were independent of the density structure. However, the actual tidal amplitudes, the mean elevation, and the vertical structure of longitudinal velocity changed considerably in the various experiments. Both cases assumed the same coefficient of bottom friction and bathymetric schematization. (5 refs)

Bodge, K. R., and Dean, R. G. 1987. Shortterm impoundment of longshore sediment transport. (See complete entry in Section II.)

Borah, D. K., and Balloffet, A. 1986. Sediment routing model for estuarine harbors. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:443-452. University, MS: University of Mississippi.

A numerical model is developed to route suspended sediment and estimate sediment concentrations and bottom deposits in estuarine harbors. Tidal flows are obtained through use of TAMS model LATIS. Both models were applied to two different harbors. One is a proposed small boat harbor at Kenai, Alaska, where the models were used to forecast the sediment deposit patterns for several harbor configurations and tidal prisms and assess the relative merits of each option. The second is the New York Harbor where the models were used to analyze the propagation of a sediment plume produced by dredging operations at Stapleton, Staten Island, New York. (8 refs)

Bose, S. K., Ray, P., and Dutta, B. K. 1987. Mathematical models for mixing and dispersion in forecasting and management of estuarine water quality. (See complete entry in Section I.)

Bose, S. K., Ray, P., and Dutta, B. K. 1988. Water quality management of the Hooghly Estuary--A linear programming model. *Water Science and Technology* 20(6/7):235-242.

Rapid and widespread deterioration of water quality in surface water systems has rendered mathematical modelling for predicting water quality indispensable especially in terms of biochemical oxygen demand (BOD) and dissolved oxygen (DO) under various system parameters. Model output under a prescribed set of conditions indicates the degree of treatment necessary to make the waste load acceptable. It also analyzes the consequences of changes in water quality objectives from a cost/benefit viewpoint. The most appropriate model in this regard would be the one which takes into account the cost of treatment plant installations and their locations. This paper proposes a linear programming model for water quality management of the Hooghly Estuary. The linear objective function for the total cost of treatment at selected terminals has been expressed in terms of quantity of BOD removed. Computed data have been presented under reasonably wide range of parameters. (22 refs)

Bottin, R. R., Jr., Outlaw, D. G., and Seabergh, W. C. 1985. Effects of proposed harbor modifications on wave conditions, harbor resonance, and tidal circulation at Fish Harbor, Los Angeles, California; Physical and numerical model investigations. Technical Report CERC-85-2. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

The Port of Los Angeles has embarked upon a program to improve wave and current conditions at Fish Harbor, Los Angeles, California. To achieve this, field measurements (both wave heights and currents) for the existing harbor were obtained and analyzed and a physical hydraulic model for short-period wave tests and numerical models for harbor oscillation and tidal circulation were used to investigate the effects of proposed harbor improvements. The proposed improvements consisted of dredging deeper channels and berthing areas to accommodate the larger, deeper draft vessels using the harbor and the creation of landfills to provide for expansion of local industry. the physical model was constructed to an undistorted scale of 1:60, model to prototype, and included the entire harbor and approximately 1,500 ft of underwater contours to the south and east of the entrance. A 30-ft-long wave generator and an Automated Data Acquisition and Control System were utilized in model operation. A hybrid finite element numerical model (capable of calculating forced harbor oscillations for harbors of arbitrary shape and variable

depth) was used to calculate harbor resonance at Fish Harbor. Four numerical finite element grids were used to compute wave-height amplification factors and normalized maximum current velocities associated with the harbor's response to incident waves ranging from 20 to 160 sec. A two-dimensional depth-averaged formulation of the hydrodynamic equations was used in the tidal circulation model, and an implicit-explicit finite difference scheme was used to numerically solve the equations. An optimum improvement plan was developed during the physical model wave tests which met the established wave-height criteria and provided increased area for mooring small craft in the lee of the harbor breakwater. The results of the long-period prototype data analysis and numerical harbor oscillation study indicated a decrease in long-period wave energy for this optimum plan. The tidal circulation study indicated that changes in tidal circulation characteristics were limited to the vicinity of Fish Harbor and included a slight shift in flood and ebb flow patterns due to the breakwater location for the optimum plan. Tidal flushing in Fish Harbor was influenced by the optimum plan but was similar to existing conditions for successive low waters. (9 refs)

Brady, J. A., Stead, R. G., and Ord, W. O. 1983. Pollution control policies for the Tees Estuary. (See complete entry in Section IV.)

Broche, P., Salomon, J. C., Demaistre, J. S., and Devenon, J. L. 1986. Tidal currents in Baie de Seine: Comparison of numerical modelling and high-frequency radar measurements. *Estuarine, Coastal and Shelf Science* 23(4):465-476.

Numerical modelling and high-frequency (HF) radar technique are two developing methods for studying coastal circulation. They both have a wide space coverage, and similar time and space discriminations (respectively a few minutes and a few square kilometres). It is therefore particularly interesting to compare their results. An experiment using two HF radars was made in Western Baie de Seine at the end of summer 1982, and three days of these measurements, covering a large range of tidal coefficients, have been compared with the corresponding results of a two-dimensional modelling of the whole bay. Characteristics of this model, as well as the main methodological and technical points concerning HF radar measurements (especially a discussion of the measurements errors, evaluated to be 3 to 7 cm s^{-1} on each radial component), are presented. A comparison is made at 6 points for the current vector, and at 20 points for one of the radial components. It concerns the half-day mode (amplitude, phase, hodograph). In most of the area, no significant phase lag is observed. The agreement is to within about 10 cm s^{-1} for the amplitude, and to within less than 10 deg for the bearing of tidal ellipses, with smaller intervals for smaller tides. This agreement shows that the intrinsic accuracy of the model is comparable to that of other sensors such as current meters. What is even more satisfactory is that the model does not use as boundary conditions any measurements specific tot he period studied except for sea level forecasts, which are given by a greater scale physical model. A significant difference is observed only close to the coast where the strong gradient of the current velocity (referred to the discrimination scale) is unfavorable both to the model and to the measurements. (12 refs)

Brockmann, C. W., and Dippner, J. w. 1987. tidal correction of hydrographic measurements. *Deutsche Hydrographische Zeitschrift* 40(6):241-260.

A simple procedure is presented to eliminate the influence of tidal oscillation from hydrographic measurements. This is done with a transformation from a coordinate system fixed in space to a coordinate system fixed in time using results of a numerical tidal model. The procedure is applied to a hydrographic survey in the German Bight. The hydrographic structure transformed onto a coordinate system fixed in time is much more similar to the structure obtained by satellite pictures and shows dynamic processes much clearer than in a coordinate system fixed in space. (11 refs)

Brogdon, N. J., Jr. 1986. Estuary model test evaluation. (See complete entry in Section VIII.)

Brogdon, N. J., Jr., and White, D. M. 1985. Newburyport Harbor, Massachusetts; Report 2, Design for hydrodynamics, salinity, and sedimentation; Hydraulic model investigation. Technical Report HL-79-1. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Newburyport Harbor Model, a fixed-bed model with provisions for conversion to a movable-bed model, was constructed to scales of 1:300 horizontally and 1:100 vertically and reproduced all of Newburyport Harbor, the Merrimack River to the head of tidal influence, and a portion of the Atlantic Ocean adjacent to the harbor entrance. The model was equipped with the necessary appurtenances for accurate reproduction and measurement of tides, tidal

currents, salinities, freshwater inflows, density effects, and other important prototype phenomena. Verification tests were conducted to make certain that the model hydraulic and salinity regimens agreed with those of the prototype. The agreement attained between similar model and prototype values was considered satisfactory. A second verification phase was completed and accepted in which shoaling and scour patterns in the entrance area for periods of 6 months and 1 year were simulated. the purpose of the model study was to determine the effects of proposed improvement plans on existing hydraulic, salinity, flushing, and entrance shoaling and scour conditions. Six plans were selected for extensive model testing. Test results consist of comparable measurements of tidal heights, current velocities, salinities, surface current patterns, dye dispersion, and shoaling and scouring for base and proposed improvement conditions. Analysis of these data indicates that none of the six plans would cause any significant overall effects to base condition tidal heights, salinities, or dye dispersion. The data analysis does indicate very significant changes in current patterns and magnitudes and in shoaling and scour in the entrance area and on the outer bar. Most effects were confined to the local area of the plan but generally influenced overall conditions throughout the estuary very little. Plans including the curved extension to the north jetty (Plans 3B, BE, and BX) would each result in a small reduction to the shoaling rates in the outer bar channel but would cause increased shoaling over the inner bar and seaward end of the channel to such a degree as to offset the gains realized in the outer bar channel. These three plans and Plan 2C would cause hazardous navigation conditions through the entrance due to the extremely high current velocities generated by the plans. Plans D and 3E had the least effects of any of the plans on entrance shoaling and scour. None of the six plans tested had any significant effect on shoaling and scour rates or patterns along the beaches and offshore areas. Each plan resulted in a general but small increase in shoaling along the eastern half of the north shoreline of Plum Island. Plan D provided complete protection of the north shoreline of Plum Island.

†**Bukatov, A. Y. , et al.** 1978. Tidal-period internal waves in the equatorial zone of the Indian Ocean. *Oceanology* 18(5):514-518 (Translated from Russian).

The result of experimental and theoretical investigations of tidal-period internal waves in the equatorial zone of the Indian Ocean are presented. It is shown that higher modes can predominate in wave motion on tidal periods. (11 refs)

†**Burrage, D. M.** 1986. Dynamics and short term variability of the Middle Atlantic Bight shelfbreak front. Ph.D. diss., University of Delaware, Newark.

Shelfbreak front dynamics in the Middle Atlantic Bight during spring and summer involve nonlinear processes (Rossby No. $R_0 \sim 0.2$) in the high subtidal, tidal and supertidal frequency bands. Models based on simplified momentum balances, such as Ekman dynamics or the thermal wind, might explain shelfbreak flows qualitatively, but are not quantitatively accurate and can be misleading. Little simplification of the momentum equation is possible and 3-D numerical models having all terms in the governing equations, with time-dependent stratification, realistic topography, and spatially variable wind forcing are needed. Summertime frontal dynamics are dominated by the seasonal pycnocline which partially decouples the surface layer from the interior, and provides a wave guide for supertidal internal solitons generated by interaction of the M2 barotropic tide with the shelfbreak. The tidal frequency bank couples nonlinearly to the subtidal motion through bottom stress enhancement, and indirectly through generation of supertidal internal waves which can enhance interfacial and bottom stress, while contributing to vertical mixing and across-shelf salt migration. Internal displacements due to supertidal interfacial waves and tidal body waves reaching 12 m and 30 m, respectively, can alias hydrographic and current measurements. In summer, when the front is weak relative to the seasonal pycnocline, and isopycnal exchange above the front is possible, a combination of supertidal wave-induced vertical mixing and nonlinear advection might explain the persistence of the S-Max (a warm saline intrusion frequently found in summertime hydrography), its diapycnal component, and its location above the seasonal pycnocline. In winter and spring the front resists warm saline intrusions which can only penetrate the front if there is strong onshore flow of slope water, as when warm core rings interact with the shelfbreak.

Butler, H. L. 1986. Advanced numerical models for coastal currents and sediment transport. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang,

H. W. Shen, and L. Z. Ding, III:1477-1485. University, MS: University of Mississippi.

Mathematical models have been developed which simulate two- and three-dimensional time-dependent currents and sediment transport in coastal, estuarine, and lake waters. The models have been applied at various locales around the United States. This paper focuses on the characteristics of a recently developed three-dimensional model and the direction of present and future research on advancing current technology. The two-dimensional (2D) hydrodynamic model is the Waterway Experiment Station (WES) Implicit Flooding Model (WIFM). It uses an extremely efficient alternating direction implicit (ADI) finite difference solution algorithm and a stretched rectilinear grid scheme for locally increasing resolution and/or aligning coordinates along physical boundaries. The Coastal, Estuarine, and Lake Currents Three-Dimensional (CELC3D) Model is an efficient three-dimensional (3D), time-dependent, free-surface model for simulation of tide- and wind-driven currents and sediment transport. To better resolve the complex geometry and bottom topography in coastal waters, vertical as well as horizontal stretchings are applied to the generally nonuniform coordinates. Special computational features of the model are (a) a time-splitting technique which separates the computation of the slowly varying internal model (3D variables) from the computation of the fast-varying external mode (water level and vertically integrated velocities), (b) an ADI algorithm for the computation of the external mode, and (c) an implicit algorithm for the vertical diffusion term of the internal mode equations. CELC3D was developed as a generalized model to improve Corps of Engineers ability to design and test coastal projects including structures, channel alignment and maintenance, and open water disposal site analysis. Results from an application to the highly complex Mississippi Sound and adjacent waters will be presented. Recent developments include extending applicability of the model to a generalized horizontal curvilinear grid. The key feature of the approach taken is the transformation of the physical velocity components into their corresponding contravariant flow components. This permits a more appropriate specification of boundary conditions. Some initial results will be presented and future research objectives discussed. (7 refs)

Butler, H. L. 1982. Numerical modeling of inlet-estuary systems. In *Proceedings of the conference applying research to hydraulic practice,* 17-20 August 1982, Jackson, MS, ed. Peter E. Smith, 715-726. New York: ASCE.

The Army Corps of Engineers, as part of its mission, has had to address various problems (hazardous navigation conditions, shoaling and erosion problems, etc.) associated with tidal inlet hydraulics and to propose improvement alternatives. This presentation discusses the use of a two-dimensional numerical model (WIFM) for simulating tidal hydrodynamics for existing and plan conditions. To achieve a solution of the governing equations, alternating direction implicit (ADI) finite-difference techniques are employed on a stretched rectilinear grid system. The model predicts vertically integrated flow patterns as well as the distribution of water-surface elevations. Code features include the treatment of regions that are inundated during a part of the computational cycle, subgrid-scale barrier effects, and a variety of permissible boundary conditions and external forcing functions. An application of WIFM is presented to demonstrate model usage in treating inlet-estuarine system problems. Elements of improvement plans tested in the various models include installations of jetties (with and without low weir sections), bulkheads, and training groins; channel construction and maintenance; and marine developments. (3 refs)

Butler, H. L., and Sheng, Y. P. 1982. ADI procedures for solving the shallow-water equations in transformed coordinates. In *Proceedings of the 1982 Army numerical analysis and computers conference,* 3-4 February 1982, Vicksburg, MS, 365-380. ARO Report 82-3. Research Triangle Park, NC: US Army Research Office.

In order to study the dynamic response of coastal water to tides (astronomical or storm induced), tsunamis, and/or meteorological forcing, a two- or three-dimensional free-surface time-dependent model is often desired. However, most such models require an exceedingly small time-step (associated with the propagation of gravity waves over the distance of a horizontal grid spacing), and hence their applications are limited. For model efficiency, alternating direction implicit (ADI) procedures are used to solve the vertically integrated equations of momentum and continuity for the two-dimensional model as well as for the external mode of the three-dimensional model. A major advantage of the subject models is the capability of applying a horizontal coordinate transformation in the form of a piecewise exponential stretch. This procedure results in the application of a smoothly varying grid to a given study region permitting simulation of a complex landscape by locally increasing grid resolution and/or aligning grid coordinates along physical boundaries. Reference is

drawn to various applications of the two-dimensional model. (15 refs)

Butler, R. A., Covington, A. K., and Whitfield, M. 1985. The determination of Ph in estuarine waters; II: Practical considerations. *Oceanologica Acta* 8(4):433-439.

Experimental studies in the laboratory and in the field indicate that the use of cells incorporating a free-diffusion liquid junction minimizes systematic errors in Ph measurements in estuarine waters and enhances the measurement precision. A procedure employing a flow cell and sampling via a syringe is described and representative field results are presented. The procedure described is readily automated and adapted for continuous measurement in the field. the use of the flow cell enables results with a precision and accuracy of ± 0.01 Ph to be obtained on a routine basis with electrode calibration at the beginning and end of each working day. (10 refs)

Caillat, J.-M. 1983. Effect of salinity on deposit distribution in estuarian channels. (See complete entry in Section III.)

Câmara, A. S., da Silva, M. C., Ramos, L., and Ferreira, J. G. 1967. Tejo 1--An interactive program for the division of estuaries into homogeneous areas. *Water Science and Technology* 19(9):43-51.

The division of an estuary into homogeneous areas from both hydrodynamic and ecological standpoints is essential to any estuarine basin management model. This paper presents an approach based on a heuristic algorithm to achieve such a division. The methodology implemented through an interactive computer program named Tejo 1 applies morphological, water quality, and management criteria in order to achieve the disaggregation. The approach is equally applicable to river or lake basins, with only minor adaptations. An application of Tejo 1 to the Tejo estuary is included for illustrative purposes, which resulted in the final division of the estuary into 11 homogeneous areas. (6 refs)

Cameron, I., and Ho, G. E. 1985. Disposal of wool scouring effluent in an estuarine environment. (See complete entry in Section IV.)

Cannon, G. A., Bretschneider, D. E., and Holbrook, J. R. 1984. Transport variability in a fjord. (See complete entry in Section II.)

Carson, B., Ashley, G. M., Lennon, G. P., Weisman, R. N., Nadeau, J. E., Hall, M. J., Faas, R. W., Zeff, M. L., Grizzle, R. E., Schuepfer, F. E., Young, C. L., Meglis, A. J., Carney, K. F., and Gabriel, R. 1988. Hydrodynamics and sedimentation in a back-barrier lagoon-salt marsh system, Great Sound, New Jersey -- A summary. (See complete entry in Section II.)

Carson, B., Carney, K. F., and Meglis, A. J. 1988. Sediment aggregation in a salt-marsh complex, Great Sound, New Jersey. (See complete entry in Section II.)

Castillo, F. P. 1983. Historical coastaline changes at the southern shore of the Gulf of Venezuela. (See complete entry in Section V.)

Central Board of Irrigation and Power. 1988. Tidal power development. *Irrigation and Power* 45(2):33-49.

An International Symposium on Tidal Power Development was held at Vigyan Bhawan, New Delhi, on 16-18 February 1988. The seminar, sponsored by Central Electricity Authority, was organized by Central Board of Irrigation and Power. The general findings and recommendations of the symposium include the following: (a) The present state of tidal power development technology is considered adequate to evolve cost-effective design and construction methodologies for tidal civil structures. Similarly considerable advancements have taken place in the hydro-mechanical equipment to make tidal power an attractive alternative. (b) For the proposed first Indian Tidal Power Project in the Gulf of Kachchh, extensive investigations and data collection have been carried out which could be considered as a good data base for the current techno-economic feasibility study. (c) Conceptual designs developed for various civil structures appear to be in order. For the construction of powerhouse and sluiceways, the floated-in-caisson construction technique is considered feasible. However, to arrive at the optimum design and construction method for the caissons, various alternatives need to be studied in detail. (d) Supplementary investigations including underwater core drilling and detailed mathematical and physical model studies will have to be carried out to evolve detailed designs and optimum construction sequence and techniques for the tidal barrier. (e) The energy consumption and optimization studies carried out for the Kachchh Tidal Power Project (KTPP) are considered sufficiently accurate which is also confirmed by

comparison of the results of the study with the optimization curves evolved on the basis of similar studies carried out for other tidal power plants in the world. However, the multi-tide dynamic model may also be applied although overall difference in the resulting energy may not exceed 2 percent. (f) The construction of a main tidal barrier across Hansthal Creek would not have any adverse effect on the flow conditions at Kandla Port or on its approaches. However, more detailed model studies, including mobile bed model studies, need to be carried out to evolve the type of control structures across Phang, Sara and Sanu Creeks and the likely impact of the tidal barrier on sediment dynamics in the approaches to Kandla Port. (g) The construction of the main tidal barrier at the proposed location in the Hansthal Creek does not result in any reduction of the tidal range which is a plus point for the proposed KTPP. (h) For single effect ebb generation with pumping, a fixed distributor and adjustable blade bulb turbine are considered to be the optimum choice. However, for tidal power schemes where pumping is not found to be attractive, a bulb unit with adjustable blades or straflo unit is considered most suitable, the latter having an edge over the bulb. With the present status of technology a bulb or straflo unit up to 9 m runner diameter can be considered feasible. (i) The proposed tidal power project in the Gulf of Kachchh is not likely to have any adverse impact either on man or on environment. Instead several socio-economic benefits are likely to accrue to the region in addition to energy generation.

†**Chabert D'Hieres, G., and Le Provost, C.** 1977. Synthesis of determinations of the principal tidal components in the English Channel, resolved with the aid of the Grenoble scale model. (See complete entry in Section I.)

Chaloin, B., Péchon, P., and Coëffé, Y. 1985. Hydraulic studies of the bed evolution of the River Canche Estuary and of the Dunkirk Harbour extensions. In *International conference on numerical and hydraulic modelling of ports and harbours,* 23-25 April 1985, Birmingham, England, ed. J. H. Pounsford, 51-64. Cranfield, Bedford, England: BHRA, The Fluid Engineering Centre.

Two studies are presented: the examination of the morphological evolution in the River Canche Estuary and the extension of the West Dunkirk Harbor. The bed evolution of the River Canche Estuary has been estimated by using numerical models; at first tidal currents have been computed and then transport and resulting seabed changes have been deduced. The impact of a local protection project has been examined. Tidal currents inside the West Dunkirk Harbor have been computed to estimate modifications in navigational conditions and sedimentological problems. Preliminary agitation computations have been done to choose the best geometric extension configuration. The final configuration has then been tested on a physical model. Bank and dike protections have been checked. (7 refs)

†**Chatterjee, A. K., and Debnath, L.** 1978. Nonlinear mathematical model of inhomogeneous tidal rivers. *Journal of Computational and Applied Mathematics* 4(3):223-227.

An implicit nonlinear model of a tidal river has been developed, taking into account the inhomogeneity of the fluid due to salinity intrusion. A high degree of mixing is supposed, so as to regard the salinity in the vertical direction and the longitudinal dispersion coefficient as constant. The continuity and momentum equations are coupled through a simplified equation of state linking the density to concentration. The model scheme is stated to be unconditionally stable, whatever the choice of the space and time increments upon which accuracy depends. An application to data from the Hooghly River shows good agreement in gage curves as well as for the salinity and density variations with time at different stations.

†**Chatterjee, A. K., and Debnath, L.** 1978. Study of nonlinear wave propagation in tidal rivers. *Acta Mechanica* 30(1/2):129-135.

A nonlinear model of tidal wave propagation in a river is studied with a computer-based numerical model using the method of characteristics. This model is applied to the Hooghly River, and the computational results are compared with these observed in the river. It is shown that the computed tidal elevations are in excellent agreement with the observed data in the river. Attention is given to the propagation of spring tides which turn into bores in the river portion from Fulta to Calcutta where the bores are actually formed.

Chen, C. L. 1989. Analytic solutions for tidal model testing. *Journal of Hydraulic Engineering*, ASCE, 115(12):170-1714.

Any hydrodynamics model should be verified by comparing its results both with analytic solutions and field measurements. Comparing the model results with analytic solutions is essential to establish the validity of the model as a proper system simulation.

The analytic solutions can only be obtained for simplified equations and boundary conditions. Lynch and Gray presented a number of analytic solutions for computer flow model testing. Their work has established a set of test cases that can form an objective basis for model verification. However their solutions for the cases of reverse quadratic bathymetry in both Cartesian and polar geometry should be corrected. This article considers two geometry cases, one a channel with polar geometry, the other with Cartesian geometry. This article makes corrections for cases where the bathymetries are reverse quadratic. With the corrections, a set of test cases for evaluating the performance of tidal models is reformed. (2 refs)

†**Chen, C.-L.** 1985. Simulation of hydrodynamics and water quality in a well-mixed estuary by using finite element methods. Ph.D. diss., The University of Wisconsin-Milwaukee.

A deterministic hydrodynamic and water quality model for simulating the water flow and water quality constituent transport in a well-mixed estuary is developed. The model is applied to the real-time simulation of hydrodynamics and water quality of the Green Bay and Lower Fox River estuarine system. The hydrodynamic simulation is made based on solving the shallow-water equations using finite element methods. The Galerkin's approach for the finite element method is applied to the spatial approximation of variables. A modified leapfrog scheme is applied for the time-stepping. This scheme is efficient and conditionally stable but neutrally stable for the short numerical waves in the prototype simulation. An additional modification eliminates the short numerical waves by using the force terms of the continuity equation with the water depth at the old time level. The combined new modified leapfrog scheme is efficient, conditionally stable, accurate, and wiggle free. The water quality simulation is made based on solving the vertically averaged convective transport equation using the finite element methods. The Galerkin's approach is applied to the spatial approximation of the convective transport equation. The direct use of Taylor series expansion to second-order derivative in time has resulted in a numerical scheme which introduces balancing tensors into the convective transport equation to compensate for the truncation error due to the forward difference stepping. The scheme is conditionally stable and second-order accurate. The hydrodynamic and water quality model is calibrated and confirmed using the extensive data available in the Lower Green Bay and Fox River system. There are nine water quality parameters included in the model, which are dissolved oxygen, algae, carbonaceous biochemical oxygen demand (two terms), ammonia nitrogen, nitrate nitrogen, organic nitrogen, phosphorus, and temperature. The reactions and interactions of these water quality parameters are mathematically described in the model for the system.

Chen, H. S., and Unkulvasapaul, Y. 1986. Simulation of suspended/dissolved biogeochemic loads in the James Estuary, Virginia. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:354-363. University, MS: University of Mississippi.

Real-time one-dimensional hydrodynamic and biogeochemic models developed for a yearlong simulation of suspended/dissolved biogeochemic loads in the James Estuary in Virginia are presented. The models are based on the continuity and momentum equations for fluid motion and the conservation of mass equation for salt and each biogeochemic constituent. The biogeochemic constituents in the simulation are chlorophyll a, organic nitrogen, ammonia nitrogen, nitrite-nitrate nitrogen, organic phosphorus, inorganic phosphorus, carbonaceous biochemic oxygen demand (CBOD), and dissolved oxygen (DO). The simulation appears satisfactory, given the ability of the model to reproduce observed time variation in current, water level, and concentrations of the biogeochemic constituents. (8 refs)

Cheng, R. T. 1986. Modeling of estuarine hydrodynamics—A mixture of art and science. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:1468-1476. University, MS: University of Mississippi.

Estuarine hydrodynamics is one of the most complex subjects in environmental flow problems, and the task of modeling estuarine hydrodynamic processes is most challenging. The flow field in an estuary is always transient, and usually is stratified and multidimensional. There are more than one characteristic length scale and time scale involved in any given estuarine flow problem. For a proper description of estuarine hydrodynamics by a computer model, the characteristic scales of the model must be compatible with the characteristic spatial and temporal scales of the processes of interest, and with that of the

available data. A modeling task for estuarine hydrodynamics must sustain, at least, the following three main features: (a) a realistic description of the estuarine processes, (b) a practical method of solution, and (c) an effective method for presentation of model results. A successful modeling task calls for a thorough understanding of estuarine physical oceanography, a pragmatic approach to numerical methods, and an artistic skill to graphically illustrate the model results. In order to accomplish these objectives, research of estuarine hydrodynamic modeling requires a mixture of art and science. This modeling viewpoint will be illustrated using hydrodynamic models developed for San Francisco Bay, California, U.S.A., as examples. (25 refs)

†**Cheng, R. T., and Walters, R. A.** 1982. Modelling of estuarine hydrodynamics and field data requirements. *Finite elements in fluids,* ed. R. H. Gallagher, D. H. Norrie, J. T. Oden, and O. C. Zienkiewicz, 4:89-108. New York: Wiley.

This source notes the importance of identification of characteristic length and time scales in modelling environmental hydrodynamics and discusses principles of modelling. It uses field and modelling studies of San Francisco Bay, California, U.S.A, to demonstrate data requirements for a tidal circulation model and residual circulation model and residual circulation model. It presents the governing equations used, initial and boundary equations, and Galerkin finite element method of solution. It discusses treatment of time and spatial scales, noting implications for modelling ecological processes.

Chenin-Mordojovich, M. I., and Usseglio-Polatera, J. M. 1987. Numerical problems in coupling two- and three-dimensional models: The CYTHERE 3D system. In *Turbulence measurements and flow modeling,* ed. C. J. Chen, L.-D. Chen, and F. M. Holly, 365-374. Washington, DC: Hemisphere Publishing Corporation.

CYTHERE 3D is a new modelling system coupling CYTHERE ES1 and ODYSSEE. CYTHERE ES1 is a 2-D tidal current modelling system developed jointly by Electricité de France National Hydraulics Laboratory (EDF-LNH) and SOGREAH. The governing equations are the complete 2-D shallow-water wave equations with additional terms for gradient diffusion of horizontal momenta. ODYSSEE is a 3-D modelling system developed by EDF-LNH, and the governing equations are the complete 3-D shallow-water wave equations. The split operator approach makes the connection easier but different expressions for bottom friction momentum sink have given rise to some difficulties. CYTHERE 3D, including the IRG (Internal Refined Grid) system, a grid refinement with simultaneous resolution, will allow 3-D computations on specific areas displaying significant 3-D tendencies with reasonable accuracy and cost. (5 refs)

†**Chevereau, C., and De Sogreah, M.** 1977. Mathematical models applied to the study of morphological processes and pollutant propagation in coastal regions. *Annales Hydrographiques* 5(1):215-227 (In French).

The use of mathematical models for studies concerning coastal regions subjected to tidal action has developed rapidly in the period 1963-1970. The first part of this paper reviews the state of the art in studies of tidal wave propagation in two dimensions and in numerical methods of solving equations which describe such phenomena. The results of tidal calculations have been used to simulate morphological processes and the dispersion of pollutants. It is shown that the physical model and the mathematical model are complementary techniques, and their advantages and limitations are studied and illustrated by reference to an investigation of the Seine Estuary. Problems in applying tidal calculations to pollutant propagation are discussed and illustrated by reference to a mathematical modelling exercise carried out on the Gulf of Morbihan.

Chu, W.-S., Barker, B. L., and Akbar, A M. 1988. Modeling tidal transport in the Arabian Gulf. *Journal of Waterway, Port, Coastal, and Ocean Engineering,* ASCE 114(4):455-471.

This paper reports a numerical modeling study of tidal transport in the Arabian Gulf. Due to the large surface area and relative shallowness of the gulf and the limiting computing resources, a two-dimensional depth-averaged model and a coarse spatial resolution of 19.05 km was used in the study. The model calculated tide ranges, and phases of low and high tides compared favorably with tide table data. To provide further insight into transport in the gulf, an Eulerian-Lagrangian Advection Dispersion (ELAD) model was developed and applied. Using velocity and depth information calculated from the hydrodynamics model, the ELAD model was used to characterize transport in the Gulf through a number of simulated tracer release scenarios. The study results reveal complex circulation patterns within the gulf and suggest a slow exchange rate between the waters of the Arabian Gulf and the Gulf of Oman. Refined spatial

resolution by the model and increased field observations are recommended for a more detailed calculation of tidal transport in the gulf. (30 refs)

Chu, W.-S., and Yeh, W. W.-G. 1985. Calibration of a two-dimensional hydrodynamics model. *Coastal Engineering* 9(4):293-307.

This paper reports the approach and results of calibrating a two-dimensional hydrodynamics model. The model was applied to Humboldt Bay, California, and calibrated with synoptic tidal data at four locations. The model calibration was done by using both a trial-and-error approach and a parameter identification (PI) method. For the given finite-difference grid resolution and field observations, the calibration attempt revealed that the two methods produced two different sets of parameters, but with almost identical comparisons between the model solutions and observations. The study results indicate that the appropriate range of model parameter values can be more efficiently identified by parameter identification method, and the best calibration strategy is to use both methods conjunctively. (22 refs)

Chu, Y.-H., and Chen, H. S. 1985. Bechevin Bay, Alaska, inlet stability study. Miscellaneous Paper CERC-85-5. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

This report defines the stability of Bechevin Inlet, Alaska, as a part of the evaluation program for a potential navigation improvement project. The net flow transport, tidal prism of spring tide, and littoral transports are calculated with mathematical models based on published data. Conclusions and recommendations are given. (22 refs)

†**Chuang, W.-S., and Swenson, E. M.** 1981. Subtidal water level variations in Lake Pontchartrain, Louisiana. (See complete entry in Section VIII.)

Cialone, M. A. 1986. Yaquina Bay, Oregon, tidal and wave-induced currents near the jettied inlet; Numerical model investigation. Miscellaneous Paper CERC-86-14. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

The Coastal Engineering Research Center of the U.S. Army Engineer Waterways Experiment Station (WES) was requested by the US Army Engineer District, Portland (NPP), to model the coastal current regime in the vicinity of the Yaquina Bay entrance, with the major emphasis on tidal and wave-induced currents at the north jetty tip. This report describes the application of the WES Implicit Flooding Model (WIFM), the Regional Coastal Processes Wave Propagation Model (RCPWAVE), and the wave-induced current model (CURRENT) to the Yaquina Bay area. The purpose of the report was to provide design guidance to MPP for the rehabilitation of the collapsed outer portion of the north jetty. Alternative plans for rehabilitation of the north jetty were modeled to determine their effectiveness in altering the current patterns near the north jetty tip. (7 refs)

†**Cifuentes, L. A.** 1987. Sources and biogeochemistry of organic matter in the Delaware Estuary. Ph.D. diss., University of Delaware, Newark, DE.

The biogeochemistry of organic matter in Delaware Estuary sediments was studied emphasizing seasonality. Suspended particulate matter and bottom sediments were characterized by determining elemental, molecular (pyrolysis GC-MS), isotopic ($\delta^{13}C$ and $\delta^{15}N$), and lignin composition. Carbon and nitrogen fixed by phytoplankton were the major sources of organic matter to the estuary. Seasonal differences were not found in the relative inputs of marine and terrestrial organic matter. Organic content in suspended particulate matter was greatest in the lower estuary and varied seasonally. Bottom sediments had much lower organic content. The C:N in suspended particulate matter indicated marine organic matter. Bottom sediments had higher C:N. Stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope ratios of suspended particulate matter were generally consistent with marine organic matter. During spring, however, isotopic fractionation of ammonia by phytoplankton at high concentrations resulted in more positive $\delta^{15}N$ in organic matter. Similarly, more positive $\delta^{13}C$ values were related to increased primary production. A mixing model, which used fresh and detrital end-members, explained isotopic abundances in suspended particulate matter. The $\delta^{13}C$ values were related to increased primary production. A mixing model, which used fresh and detrital end-members, explained isotopic abundances in sus- pended particulate matter. The $\delta^{13}C$ in bottom sediments were equivalent to isotopic ratios in suspended particulate matter; however, a 2°/oo difference existed for $\delta^{15}N$. Lignin oxidation product analysis confirmed that the terrestrial component in water column sexton is small. Lignin content increased by a factor of three in bottom sediments, explained by selective degradation of planktonic organic matter. Gymnosperm woods and nonwoody angiosperms were predominant vascular plant types in the sediments. A diagnostic model that included fractionation by phytoplankton at high ambient HN_4

concentrations explained isotopic variability. Finally, a simple box model for nitrogen cycling in the lower estuary indicated that planktonic production was deposited in the sediments in spring, and recycled back to the water column in fall.

Cole, P., and Miles, G. V. 1983. Two-dimensional model of mud transport. *Journal of Hydraulic Engineering,* ASCE, 109(1):1-12. Discussion by Emmanuel Partheniades, and Closure by Peter Cole and Gordon V. Miles, 110(3):364-367.

A two-dimensional-in-plan finite difference model is presented which models the transport of well-mixed cohesive sediments in estuaries and coastal waters. A description of each of the physical processes incorporated in the model is given. An erosion mechanism is not included explicitly because of the difficulties involved in a realistic formulation. Instead, areas of net deposition throughout a tidal cycle are identified, and rates of mud deposition within these areas are predicted. Two applications of the model to siltation studies are presented, involving different modes of operation of the model. In each case, field data in the form of bed core samples were available, so that the models could be both verified and calibrated. under these circumstances, the model can be used to make useful engineering predictions such as projected dredging requirements in estuaries and ports. (13 refs; discussion, 14 refs; closure, 1 ref).

Collins, M. B., and Ferentinos, G. 1984. Residual circulation in the Bristol Channel, as suggested by Woodhead sea-bed drifter recovery patterns. (See complete entry in Section I.)

Computer model of estuaries. 1982. *Hydro Delft* 62:19-20.

This article is a very brief, basic introduction to the use of computers in modeling estuarine flow phenomena.

Copeland, R. R. 1986. San Lorenzo River sedimentation study; Numerical model investigation. Technical Report HL-86-10, Vicksburg, MS: US Army Engineer Waterways Experiment Station.

A one-dimensional numerical model (HEC-6) was used to determine the effects of sediment deposition and erosion for a 2-mile reach of the San Lorenzo River in Santa Cruz, California. The numerical model was calibrated to simulate measured degradation and aggradation that occurred during a major flood event in 1982. The bed profile and water-surface elevations were calculated for the Standard Project, 100-year, and 50-year floods. Average annual deposition quantities were estimated for various initial channel conditions. (24 refs)

Corapcioglu, M. Y. 1987. Pressure change and surface expansion in salt marshes due to tidal inundation. (See complete entry in Section II.)

Costa, S. L., Landsteiner, M. C., Stork, J. W., and Gould, T. C. 1982. Discharge-displacement calculations for tidal flushing. (See complete entry in Section VIII.)

Craig, P. D. 1988. A numerical model study of internal tides on the Australian Northwest Shelf. *Journal of Marine Research* 46(1):59-76.

Models of internal tides have been difficult to apply to realistic ocean situations because of restrictive assumptions on the form of either the bottom topography or the vertical density structure. A numerical model, based on the analytic model of Craig, is applied to a section through the Australian Northwest Shelf, and the results compared with data collected at the North Rankin location. The model simulates accurately the amplitude and phase structure of the internal tide. The predicted temperature and current amplitudes are within one-third of those observed, but the phase relationship between the temperature and surface tide is different from that estimated from the data. The regions of strongest internal tidal generation are identified, by estimating numerically the horizontal energy flux, to be in water considerably deeper than the shelf break. (27 refs)

Cuff, W. R., and Tomczak, M., Jr., ed. 1983. *Synthesis and modelling of intermittent estuaries; A case study from planning to evaluation.* New York: Springer-Verlag.

From 1973 to 1978 scientists from several organizations in Australia conducted an ambitious study of a small marine embayment, called the South West Arm (SWA), about 30 km south of Sydney, New South Wales. The initial aim of the study was to construct a dynamic model of the carbon flows of this system, considered typical of Australian estuaries. Much of the early work of the project involved the development of experimental techniques to measure the transfers between compartments. The book contains a summary of some of the information obtained during the study period of this small estuary, characterized by highly intermittent river discharge and tidal exchange. The geology and basic

hydrodynamics of the estuary are described as well as phytoplankton and microbenthos production and zooplankton grazing and respiration. Partial contents: Introduction to the Port Hacking Estuary Project, by K. Radway Allen (4 refs); History and organization of the Port Hacking Estuary Project, by R. R. Parker, D. J. Rochford, and D. J. Tranter (24 refs); Geological aspects of the Port Hacking Estuary, by A. D. Albani, P. C. Rickwood, J. W. Tayton, and B. D. Johnson (9 refs); Tidal flushing and vertical diffusion in South West Arm, Port Hacking, by J. S. Godrey (22 refs); Data base for the Port Hacking Estuary Project: Parameters, monitoring procedure, and management system, by D. J. Vaudrey, F. B. Griffiths, and R. E. Sinclair (20 refs); An evaluation of the dynamic information for South West Arm, Port Hacking, by W. R. Cuff (36 refs); Ecosystem modelling of South West Arm, Port Hacking, by R. E. Sinclair, W. R. Cuff, and R. R. Parker (31 refs); An evaluation of the Port Hacking Estuary Project from the viewpoint of applied science, by W. R. Cuff (44 refs); Some conclusions from the Port Hacking Estuary Project, by M. Tomczak, Jr. (21 refs).

Dal Secco, S., Hauguel A., Latteux, B., and Esposito, P. 1985. A finite element method for storm surge and tidal computation. In *International conference on numerical and hydraulic modelling of ports and harbours,* 23-25 April 1985, Birmingham, England, ed. J. H. Pounsford, 93-100. Cranfield, Bedford, England: BHRA, The Fluid Engineering Centre.

The current progress in developing a finite element method for the shallow-water equations is presented. Special attention is paid to the implementation of a semi-implicit scheme and the use of an incident wave condition. The implementation of a semi-implicit scheme makes it possible to avoid wave damping when simulating wave propagation on broad areas with a limited number of nodes in a wave length. The possible use of incident wave condition, the consideration of the atmospheric forcing terms, as well as the use of spherical coordinates qualify the model to examine the generation and propagation of storm surges. Different realistic applications are presented concerning tidal or storm surge simulations. (8 refs)

Davies, A. M. 1985. A three-dimensional model of the northwest European continental shelf, with application to the M_4 tide. *Journal of Physical Oceanography* 16(5):797-813.

The solution of the fully nonlinear three-dimensional hydrodynamic equations in polar coordinates for tides is developed using a finite-difference grid in the horizontal and the Galerkin method in the vertical. Using this method a three-dimensional model of the northwest European continental shelf is used to investigate the spatial distribution of the M_4 tidal elevations and currents over the shelf. Computed M_4 currents are compared with observations and found to be in good agreement in the Celtic Sea, although there are significant errors in the North Sea. The reasons for these discrepancies and the spatial and depth variations in the M_4 currents are discussed in detail. (16 refs)

†Debnath, L., and Chatterjee, A. K. 1978. Nonlinear mathematical model of the propagation of tides in interlacing channels. *Acta Mechanica* 31(1/2):101-116.

This paper deals with the problem of tide propagation in channels with branches. A mathematical model is developed using an explicit finite difference method based on the leap-frog operator. the grid scheme is chosen to accommodate any complicated river network with any number of junctions. The mathematical model was applied to tidal computation for the Hooghly-Rapnarain river system from Diamond Harbour area. Generally, good agreement was obtained between model computations and prototype measurements.

†Debnath, L., and Chatterjee, A. K. 1981. Two dimensional nonlinear wave propagation in a shallow tidal estuary. *Acta Mechanica* 41(1/2):11-22.

A study is made of a two-dimensional mathematical model of nonlinear wave propagation in a shallow tidal estuary using an unconditionally stable numerical scheme. The alternative direction implicit scheme is used to investigate the simulation of the flow pattern of the estuary and to examine the effects of the changes in the bed topography, either due to dredging or due to construction of spurs and guide walls in tidal flows. The Coriolis force due to rotation of the earth is taken into account in the present two-dimensional model. It is shown that the Coriolis force is responsible for the existence of the transverse component of the flow field. The proposed theoretical model is applied to investigate the flow structure in the Hooghly Estuary. The computed results are then compared with the observed values in the Hooghly Estuary. A stability analysis of the alternative direction implicit scheme is also included.

de Boer, P. L., van Gelder, A., and Nio, S. D., eds. 1988. *Tide-influenced sedimentary environments and facies.* (See complete entry in Section II.)

D'Elia, C. F. 1987. Nutrient enrichment of the Chesapeake Bay: Too much of a good thing. (See complete entry in Section IV.)

Dejak, C., Lalatta, I. M., Messina, E., and Pecenik, G. 1987. Steady-state achievement by introduction of true tidal velocities in a pollution model of the Venice Lagoon. *Ecological Modelling* 37(1/2):59-79.

Data on the velocities of tidal currents to be used as input for an advection-diffusion model of the central part of the Venice Lagoon are obtained through interpolation by means of a pre-existing hydrodynamic model. Problems discussed include interpolating procedure and choice of points to calculate velocity vectors for the integration formula "donor cell," as well as the least square optimization of both position and mutual orientation of the two grids. Using interpolated velocities, a steady state was attained after about forty semidiurnal tidal cycles; spatial distributions of pollutant at different tidal stages, as well as their arithmetic mean, are reported. Concentration profiles of the averaged distribution are shown to be substantially similar to those caused by a pure eddy-diffusion process originating from an apparent source spatially shifted from the real one. Causes for the shift are analyzed and the development of a three-dimensional diffusion model is anticipated, with tide-vorticity embodying an eddy-diffusion constant, calibrated upon the achieved steady state. The effect of "numerical diffusion" is also discussed: this effect, in spite of the rather high Reynold's cell number involved in the numerical integration, is shown to be negligible in real circumstances. (19 refs)

Dejak, C., Lalatta, I. M., Messina, E., and Pecenik, G. 1987. Tidal three-dimensional diffusion in a model of the Lagoon of Venice and reliability conditions for its numerical integration. *Ecological Modelling* 37(1/2):81-101.

A three-dimensional model of the central part of the Venice Lagoon is presented: the model is of a pure eddy-diffusion type and embodies tidal mixing action on pollutant transport. The model's asymptotic evolution to the steady state is examined, and it is shown that a pure diffusive process can achieve stationarity only in a system having more than two dimensions. Stability and consistency analysis of the implicit integration methods indicates that the two-time-levels Laasonen scheme is the most suitable for performing the integrations. Because of the closed vertical boundaries and of the larger vertical diffusion number, in respect to the horizontal, in a first version of the model, Laasonen's scheme is adopted for only vertical diffusion. After solving the problems posed by nonlinear conditions at the "open" boundaries, the scheme is applied also for diffusion along all spatial coordinates. The diffusion constant adopted in the model is obtained by calibration with a previously developed advection-diffusion model. (20 refs)

Delft Hydraulics Laboratory. 1983. Mathematical modelling of estuarine phenomena. *Hydro Delft* 67:3-8.

This article discusses the important role estuaries play in the economy. Hydraulically speaking, estuaries are far from simple. The tide penetrates, causing the water to rise and fall and to flow in and out with the regularity of its astronomical cause. Estuarine research is a difficult job for which often still complex hydraulic scale models are used. However, the development of mathematical modelling techniques made it possible to tackle gradually more estuarine problems. The basis for these studies are mathematical models describing the water movement in the system. One-dimensional models are being applied, but although they are inexpensive to use, their applicability is limited. They cannot simulate density-induced currents properly, while also most estuaries have a complex geometry. Therefore, a proper simulation of estuarine flows calls for two-dimensional modelling in the vertical sense in case of a stratified system or in the horizontal sense in the case of a well-mixed wide estuary with tidal flats and deep channels. Data from these models simulating the hydraulics can be used as an input for models of the influence of infrastructural works, salt intrusion, the effect of waste discharges, the water quality, cooling water recirculation, and sediment transports. This article illustrates the work in these fields.

Delft Hydraulics Laboratory. 1986. Special issue on estuaries and coastal seas. *Hydro Delft* 74.

Contents: Estuaries; Field studies; The tidal flume; Mathematical model development; Other experimental facilities; Measuring techniques; Oceanographic research; Tide and wind-driven water motions; Marine pollution research; Water levels in shipping routes; Determination of exceedance frequency distribution.

Delo, E. A., and Burt, T. N. 1986. Dispersion of sidecast dredge spoil: A mathematical prediction and field study. (See complete entry in Section V.)

Delo, E. A. and Ockenden, M. C. 1989. Prediction of siltation at a point. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 981-986. New York: ASCE.

This paper describes a zero-dimensional mathematical model which predicts siltation at a point on a cohesive sediment bed. The processes of erosion, deposition, and consolidation are modelled over a period of many tides. The model uses several parameters to define the sediment properties at the application point: examples are given of these relationships, which have been derived from field and laboratory experiments. An application of the model in the approach channel to a UK port is presented. (3 refs)

Dick, S. 1987. The tidal currents around the island of Sylt: Numerical investigations of the principal lunar semi-diurnal tide (M_2) (summary) (Gezeitenströmungen um Sylt. Numerische untersuchungen zur halbtägigen hauptmontide (M_2)). *Deutsche Hydrographic Zeitschrift* 40(1):25-44 (In German).

A high resolution numerical model (grid spacing: 1/3 n.m.) of the northern North Friesian Wadden Sea and the offshore sea is presented. Currents induced by the M_2 tide are described by time series of magnitude and direction of the velocity. Owing to the face that the investigations of the time series in parts of the model area reveal tidal-induced water displacements, for the whole model area the mean transports and residual currents are computed. Along the western coast of Sylt, the highest residual currents caused by the tide occur in regions of higher coastal loss. In order to examine the effect of the Hindenburgdamm on the currents around Sylt, a computation without the dam has been carried out. The comparison of the results of the computations, with and without dam, shows that the transport of water masses from the Norderaue to the Hörnum Tief is increased by the dam. Off the northwestern end of Sylt, the dam causes increased residual currents; in the rest of the Sylt offshore region, the effects on currents and water level are slight. (12 refs)

Dietrich, J., Hagstron, A., and Navntoft, E. 1983. Studies of the effect of a barrage on sedimentation. (See complete entry in Section II.)

DiLorenzo, J. L. 1986. The overtide and filtering response of inlet/bay systems. Ph.D. diss., State University of New York at Stony Brook.

This study concerns the pumping mode response of narrow inlet/bay systems to a variety of physical forcing mechanisms. In the first part of this dissertation, a simple analytical model is developed to investigate the hydraulic overtide response of tidal inlet systems. This model relates the first overtide component of the sea level response of deep (weakly nonlinear) inlet/bay systems to the relevant governing parameters. From the model phase relations between the fundamental and first overtide components, the tendency towards flood/ebb dominance is also related to the system parameters in a simple but general manner. To this end, the modelled frequency esponse for the first overtide is shown to be similar to the parent fundamental response discussed by Ozsoy. Differences between component responses include the resonant frequencies as well as the amplifications. From the model solutions for the M2 and M4 phase lags, the resulting harmonic distortions in inlet currents are determined. Systems with very short Helmholtz periods are shown to reflect the tidal distortions found at the ocean entrance, while systems with progressively greater natural periods diverge from the ocean entrance distortions in a predictable manner described by model solutions. Analytical solutions for the fundamental and first overtide component are compared to numerical solutions for verification purposes. Implications regarding the tidally induced import or export of coarse sediment in these systems are discussed. The utility of the analytical model is demonstrated for the Peconic Bay system. The analytical model describes the principal features of the Peconic Bay response and suggests a possible stability mechanism for this system. An additional model incorporating tidal variations in inlet cross-sectional area and basin surface area is proposed. This conceptual model provides a physical explanation for the observed tendency towards flood dominance in systems with time-variable cross-sectional area and ebb dominance in systems with large tidal variation in basin surface area. In the second part of this study, a more generalized form of the inlet equation is developed in order to underscore the role of an inlet/bay system as a mathematical filter in its response to ocean sea level forcing, riverine volume forcing, atmospheric pressure forcing, and baroclinically induced forcing. As such, to lowest order, an inlet/bay system is shown to have low pass characteristics which depend on the governing system parameters, with additional

resonant peaks due to the imposition of periodic forcing agents. (82 refs)

DiLorenzo, J. L., Huang, P.-S., and Najarian, T. O. 1989. Water quality models for small tidal inlet systems. *Journal of Environmental Engineering*, ASCE, 115(1):192-209.

A simplified mathematical modelling methodology is proposed for the assessment of water quality in small tidal inlet systems. Towards this objective, a quasi-steady, tidal exchange model is developed for predicting the periodic tidal variations in the concentration of conservative and decaying constituents in small, completely mixed embayments subject to steady loading and steady freshwater inflow. This model provides an inexpensive alternative to conventional multidimensional schemes and provides insight into the physical nature of the water quality response of these systems to the external forcing effects of ocean tides, freshwater inflow, and constituent loading. It is demonstrated in both theoretical arguments and by sample applications of the model that the low-pass, hydraulic filtering response of tidal inlet systems influences water quality. The model demonstrates that tidal exchange processes are less efficient in hydraulically constricted systems, which have relatively short Helmholtz periods and large inlet impedances, than in systems with long natural periods. Consequently, the model reveals a greater tendency for pollutant accumulation in systems with short Helmholtz periods. Thus, the model provides both a conceptual framework and a screening tool for assessing the susceptibility of small tidal systems to pollutant accumulation. (9 refs)

Donnell, B. P., and McAnally, W. H., Jr. 1985. Spectral analysis of Columbia River Estuary currents. (See complete entry in Section I.)

Douglass, S. L. 1987. Coastal response to navigation structures at Murrells Inlet, South Carolina; Main text and appendixes A and B. (See complete entry in Section VIII.)

Douvillé, J.-L., and Riaux, C. 1986. On the dynamics of a tidal estuary: Estimation of the principal factors (Estimation des paramètres foundamentaux de la dynamique d'un estuaire à marées). *Internationale Revue der Gesamten Hydrobiologie* 71(1):65-77 (In German).

In order to obtain a better understanding of the relationship between saltwater and freshwater masses in an estuary on the Northern Brittany coast, a study on the tidal dynamics has been carried out. A simple model for the calculation of the mean current velocities is proposed taking into account the estuarine topography, tidal parameters, and river discharge. The model also estimates the Richardson, Froude, and Reynolds estuarine numbers. These can be used in further studies on the particle transport in this estuary. (17 refs)

Dronkers, J. 1982. Conditions for gradient-type dispersive transport in one-dimensional, tidally averaged transport models. (See complete entry in Section III.)

†**Duff, G. F. D.** 1983. A special ADI model for the Laplace tidal equations. *Computers & Mathematics with Applications* 9(3):507-517.

An efficient method for numerical integration of the time-dependent Laplace tidal equations for a flat or curved earth is described. The method is implicit, uses alternating directions in two space dimensions, with time staggering, and a split sea height variable. Some special auxiliary features of the method are described, and stability is discussed.

†**Dunbar, D. C.** 1985. A numerical model of stratified circulation in a shallow-silled inlet. Ph.D. diss., The University of British Columbia, Vancouver.

A numerical model has been developed for the study of stratified tidal circulation in Indian Arm, a representative inlet on the southern coast of British Columbia. Equations for horizontal velocity, salt conservation. continuity, density (calculated as a linear function of salinity), and the hydrostatic approximation govern the dynamics. All equations have been laterally integrated under the assumption of negligible cross-inlet variability. The model is time dependent and includes nonlinear advective terms, horizontal and vertical turbulent diffusion of salt and momentum, and variations in width and depth. Provisions for surface wind stress and a flux of fresh water are also included, although neither was utilized in this study. (89 refs)

Dyson, A. R., and Druery, B. M. 1985. The impact of sand extraction on salt intrusion in the Hawkesbury River. (See complete entry in Section III.)

†**Eades, J. B., Jr.** 1978. Tidal frequency estimation for closed basins. (See complete entry in Section I.)

Elahi, K. Z., and Noor, M. A. 1983. Tidal dynamics of the Pakistani coastal water. In *International conference on coastal and port engineering in developing countries,* 20-26 March 1983, Colombo, Sri Lanka, II:1330-1339. Colombo, Sri Lanka: Conventions (Colombo) Ltd.

A numerical model is developed to investigate the effects of constructions on the tidal dynamics in harbors and coastal waters. The Sonmiani Bay was selected because field data and results of the hydraulic model were available for model testing. The model has been applied to the Indus Delta. A comparison of computed results with the observational data shows that the numerical model can accurately determine the dynamics of flow in the Sonmiani Bay. It can be applied without any difficulty to other similar cases. The numerical model is an explicit finite difference scheme applied to the vertically integrated Navier-Stokes and continuity equations. (5 refs)

†**Elliott, A. J.** 1979. A numerical scheme for predicting the location of tidally-generated fronts in shallow water. Report No. SACLANTCEN-SM-125. La Spezia, Italy: SACLANT ASW Research Centre.

A hydrodynamic numerical model is used to compute tidal currents and calculate the parameter log sub 10 (*u* to the 3rd power/*h*), where *u* is the maximum local tidal speed and *h* is the depth. A recent theory has shown that fronts, marking the boundary between stratified and isothermal water, can be expected to form where this parameter takes a critical value of about 2.2. Thus, if the amplitude and phase of the tidal elevations are known around a region of interest, then the likely location of fronts can be predicted if the bottom topography is known. As an example of the method, the scheme is applied to the Southwestern Approaches to the English Channel, and good agreement is obtained for the predicted location of a thermal front that has been observed at the western entrance during the summer months. In particular, the model shows that even eastward winds of Beaufort force 8, which occur for at least 10 percent of the time in this region, are unlikely to influence the location of the front. The computer program and instructions for its use are given in an appendix.

†**Engel, M.** 1976. The simulation of motions in the sea using numerical models: Applications and limitations. In *Inter ocean '76, proceedings, third international conference and exhibition for ocean engineering and marine sciences,* 15-19 June 1976, Dusseldorf, Federal Republic of Germany, 1:261-271. Hamburg, Federal Republic of Germany: Sechafen-Verlag Erik Blumenfeld (In German).

This presentation gives an introduction to the present state of hydrodynamical numerical modelling as far as it is concerned with the open ocean and coastal and estuarine regimes. As an example for the methods, a numerical model for long gravity waves, the so-called HN-method, is presented, which in the meantime has been applied to a variety of scientific and practical problems. Further extensions are briefly mentioned and present limitations are discussed. A number of examples are given for the tide and storm surge calculations of the North Sea. The numerical simulation of motions with a two-layer model of the North Sea shows the limitations of one-layer models with respect to velocity fields. Comparisons of results of hydraulic and numerical models are given.

†**Erasion, A., Lin, W. L., and Sharp, R. D.** 1983. FLOWER: A computer code for simulating three dimensional flow, temperature, and salinity conditions in rivers, estuaries, and coastal regions. Report No. TM-8401. Oak Ridge, TN: Oak Ridge National Laboratory.

FLOWER is a three-dimensional computer code for simulating fast transient, free surface flow, temperature, and salinity conditions in rivers, estuaries, and coastal regions. The model also includes rotational effects (Coriolis force) and is capable of accommodating wind stress coupling, a capability which enables the model to be applied to large water bodies with significant wind-driven currents, such as the Great Lakes. The mathematical formulation utilizes the integral form of the governing equations of the discrete element method. In this method, interior flow regions are represented as rectangular elements of variable size, while impermeable boundary elements are constructed from truncated rectangles, thus allowing accurate representations of complex shorelines.,

†**Essaid, H. I.** 1987. Fresh water - salt water flow dynamics in coastal aquifer systems: Development and application of a multi-layered sharp interface model. Ph.D. diss., Stanford University, Standford, CA.

A quasi-three-dimensional, finite-difference model which simulates freshwater and saltwater flow separated by a sharp interface has been developed to study layered coastal aquifer systems. Vertically

integrated freshwater and saltwater flow equations, incorporating the interface boundary condition and leakage terms calculated by Darcy's law, are solved within each aquifer. The resulting system of coupled, nonlinear partial differential equations is discretized using an implicit finite-difference scheme that is central in space and backward in time. The locations of the interface tip and toe, within grid blocks, are tracked by linearly extrapolating the position of the interface based on the known grid point elevations. The discretized system of equations is solved using the strongly implicit procedure (SIP) for three-dimensional, two-phase flow. A comparison of the coupled freshwater-saltwater flow and the Ghyben-Herzberg sharp interface approaches to the modeling of transient behavior of freshwater lenses floating on salt water has been made. The model has been used to investigate the effects of storage characteristics, transmissivity, boundary conditions, and anisotropy on the transient responses of such flow systems. The magnitude and duration of the departure of aquifer response from the behavior predicted using the Ghyben-Herzberg, one-fluid approach are a function of the ease with which flow can be induced in the saltwater region. In many common hydrogeologic settings, short-term freshwater head responses and transitional responses between short-term and long-term, can only be realistically reproduced by including the effects of saltwater flow on the dynamics of coastal flow systems. The coupled freshwater-saltwater flow modeling approach is able to reproduce the observed annual freshwater head response of the Waialae aquifer of southeastern Oahu, Hawaii. Application of the model to the Soquel-Aptos basin, Santa Cruz County, California, indicates that the saltwater flow domain exerts an important influence on the transient behavior of this layered system. Because of the slow rate of saltwater inflow into the aquifers, the interface is still responding to long-term Pleistocene sea level fluctuations and has not achieved equilibrium with present-day conditions. The rate of movement of the interface in response to the increased groundwater pumpage occurring over the past 50 years is of the same order of magnitude as the longer term responses. This has implications for coastal basin management and the potential for saltwater intrusion.

Ewertowski, R. 1988. Mathematical model of the River Odra Estuary. *Bulletin of the Permanent International Association of Navigation Congresses* 60:95-114.

In this article the author presents a mathematical model of the Odra Estuary, the aim of which is simulation of determined and undetermined processes in hydrodynamics of this estuary. First of all there have been discussed in brief the dynamic phenomena at the mouth of the Odra being of importance in the economic human activity, and the necessity of building such a model has been justified. Then the general idea of an aggregate model aimed at has been described. In later parts descriptions have been given of the actual state--the construction and operation of the model of determined and undetermined motion in the river part of the Odra Estuary and of the base of hydrological and meteorological information "HIMOS". The article has been completed by examples of results obtained for the actual swells and by conclusions and suggestions regarding the further development of work in this field. (26 refs)

†**Ewing, D. J. F.** 1982. The spreading-out of cooling water discharges from direct-cooled power stations. Leatherhead, UK: Central Electrical Research Laboratories.

This paper presents a mathematical model to describe the dispersion of cooling water discharge from a coastal, direct-cooled power station for the nearfield and midfield regions. The dynamics of the interaction between cooling water plume and ambient tidal current are considered. The model is applicable to tunnel outfalls with vertical discharges, e.g., at Sizewell "A" power station. It discusses in detail the flow buoyancy and mixing regimes, noting the presumed jet and hydraulic jump behavior. Ponding and buoyant drifting are examined. Turbulent wake effects and recirculation effects are discussed. It suggests applications of the model to the prediction of the amount of direct recirculation when a plume covers an intake and estimation of the influence of the midfield on the background temperature rise (for field model calculated).

Eysink, W. D., and Vermaas, H. 1983. Computational methods to estimate the sedimentation in dredged channels and harbour basins in estuarine environments. (See complete entry in Section V.)

†**Falconer, R. A.** 1983. Mathematical models for the water industry. *Water Bulletin* 55:8-10.

This article describes the use of a mathematical model for Holes Bay, Dorset, to investigate possible changes in water quality characteristics resulting from reclamation of part of the bay. The formulation of the model is described and the difficulty of modelling velocities and concentrations in a bay where the wetted planform area changes greatly over

the tidal cycle is considered. Comparison of mathematical model results with observations is discussed. Changes to the model are outlined and the flushing efficiency and exchange characteristics of the present and proposed bay outlines are recalculated. Other applications and advantages of such mathematical model are outlined.

Falconer, R. A. 1984. A mathematical model study of the flushing characteristics of a shallow tidal bay. *Proceedings, Institution of Civil Engineers, Part 2: Research and Theory* 77:311-332.

The paper describes the development and application of a mathematical model to compare the hydraulic features and flushing characteristics of Holes Bay in Dorset, for the present boundary configuration and for two proposed new outlines of the bay. The time-dependent nonlinear equations of mass, momentum, and advective-diffusion were solved numerically using a finite difference scheme, with the effects of the earth's rotation, bed friction, a surface wind stress, and a simple turbulence model being included in the momentum equations. The flushing characteristics of the bay were defined in terms of the tidal exchange characteristics and the degree of mixing, with a constant concentration across the bay being assumed initially. The model was run for three tides, after which time the mean and standard deviation of the remaining concentration were both determined. From a comparison of the initial and final mean concentrations, the gross tidal flushing characteristics were determined, with an indication of the degree of mixing being given by the concentration deviation. Comparisons of the corresponding results gave an indication of the effect on the flushing characteristics of the proposed new outlines of the bay. (21 refs)

Falconer, R. A. 1984. Temperature distributions in tidal flow field. *Journal of Environmental Engineering,* ASCE, 110(6):1099-1116.

The development and application of a numerical model to predict the two-dimensional depth mean velocity fields and background temperature distributions in a natural harbor, at Poole, England, is described. The predicted background temperature rises resulted from the proposed siting of either a 700- or 350-MW-capacity power station on the harbor perimeter, with the intake and outfall for the cooling water system being located along the boundary and within the harbor, respectively. The numerical model was based on the solution of the depth-integrated flow equations, simulating the tidal currents, and on the depth integration of the advective-diffusion equation for the conservation of heat. The main difficulties encountered in the hydrodynamic model included the representation of the advective acceleration terms, particularly since the harbor had a narrow entrance, and the modeling of the significant changes, which occur in the plan cross-sectional area as large regions of shallow water were dried out and flooded on each tide. The modeling difficulties associated with the heat balance equation included the numerical treatment of the temperature discontinuity at the outlet and the open seaward boundary conditions.

Falconer, R. A. 1985. Application of numerical models in the hydraulic design and operation of four U.K. harbours. In *International conference on numerical and hydraulic modelling of ports and harbours,* 23-25 April 1985, Birmingham, England, ed. J. H. Pounsford, 1-11. Cranfield, Bedford, England: BHRA, The Fluid Engineering Centre.

This paper describes the application of a generalized two-dimensional depth-integrated numerical model, which has been developed and refined to predict some of the complex hydrodynamic phenomena frequently associated with the unsteady and nonuniform tidal flows occurring in harbors and coastal basins. Various forms of the advective-diffusion equation have been added to the hydrodynamic model, allowing flushing efficiencies, temperature distributions, and nutrient levels to be evaluated for specific case histories. In the applications of the model reported in the paper, special emphasis has been placed on the finite difference representation of such hydraulics related problems as (a) tidal jet-induced circulation, (b) the flooding and drying of extensive areas of shallow marshlands, both for relatively large and small basins, (c) the treatment of constituent discontinuities at outfalls for example, and (d) rapidly opening lock gates. Comparisons have been made between numerical model results and field-measured and laboratory model results. (26 refs)

Falconer, R. A. 1985. Residual currents in Port Talbot Harbour: A mathematical model study. *Proceedings, Institution of Civil Engineers, Part 2: Research and Theory,* 79:33-53.

The paper describes the development and application of a mathematical model to predict the tide-induced circulation within a narrow-entranced harbor, which experiences exceptionally large spring tidal ranges. In the model, particular attention has been paid to the mathematical treatment of the convective

accelerations and the inclusion of the turbulent Reynolds stresses. On the dominant flood tide, the divergence of the velocity field associated with the narrow entrance jet inlet and the high velocity gradients occurring at the tip of the main breakwater resulted in pronounced secondary circulations within the harbor. The strength of these residual currents was thought to be underestimated in the mathematical model, even though the mathematical simulations indicated the persistence of these currents well into the subsequent ebb tide. The flooding and drying of relatively extensive regions of shallow water within the harbor were included in the model, and various treatments of the open boundary conditions were compared and analyzed. (21 refs)

Falconer, R. A. 1986. Water quality simulation study of a natural harbor. *Journal of Waterway, Port, Coastal and Ocean Engineering*, ASCE, 112(1):15-34.

The modification and application of a hydrodynamic water quality model to predict the water elevations, the depth average velocity components, and the depth mean nitrogen concentrations in Poole Harbor and Holes Bay, in Dorset, England, are described. The main objectives of the study are to ascertain the influence of the nitrogen discharge from Poole Sewage Treatment Works on the corresponding concentrations across the harbor. Comparisons were undertaken, both with and without nitrogen inputs from Poole Sewage Treatment Works, of the concentration distributions of total oxidized nitrogen and ammoniacal nitrogen across the harbor, for inflows from two rivers and three sewage treatment works. Limited field measurements were available of velocities and nitrogen concentrations, allowing a check on the accuracy of the model predictions. A number of difficulties had to be overcome in the hydrodynamic modeling, including treatment of the open boundary conditions, representation of the advective terms, with particular reference to the narrow harbor entrance, and simulation of extensive flooding and drying of shallow regions throughout the tidal cycle. (20 refs)

Falconer, R. A., and Owens, P. H. 1984. Mathematical modelling of tidal currents in the Humber Estuary. *Journal of the Institution of Water Engineers and Scientists* 38(6):528-542.

The paper describes a mathematical model which has been used to predict water elevations and the two-dimensional tide-induced velocity fields in the Humber Estuary. The water elevations and depth-averaged velocities were evaluated within the estuary by numerically solving the time-dependent nonlinear equations of mass and momentum in the horizontal plane using an alternating direction implicit finite difference scheme. The two depth-integrated momentum equations were formulated to include the effects of the earth's rotation, the bed resistance, a surface wind stress, and a turbulence model. In addition, efforts have been concentrated on the development of a refined modelling technique to simulate the drying and flooding of the tidal flood-plains for the relatively large grid spacing of 1 km. Comparisons have been made between the mathematically predicted and corresponding field-measured velocity variations and water elevations at two specific sites along the estuary, between the two open boundaries of the model. The resulting comparisons have shown an encouraging agreement, particularly in view of the coarseness of the grid spacing, and consequently the coarse representation of the bathymetry, and the lack of appropriate bed resistance data. (13 refs)

Falconer, R. A., and Owens, P. H. 1987. Numerical simulation of flooding and drying in a depth-averaged tidal flow model. *Proceedings of the Institution of Civil Engineers* 83(2):161-180.

A refined numerical modelling scheme to simulate the flooding and drying of shallow estuarine reaches by repetitive tides is described. Interest has been focused on developing a technique which can be applied to relatively large grid space and time-step models, and which may be particularly relevant to nested hydrodynamic modelling. Details are given of comparisons of water elevation predictions obtained for two different approaches in modelling flooding and drying, for an idealized one-dimensional estuary with a uniformly sloping bed and with extreme grid and time-step sizes. As a result of these comparisons, a refined scheme which is particularly relevant to less time restrictive implicit models has been proposed. The proposed flooding and drying simulation technique has been applied to a two-dimensional coarse grid model of the Humber Estuary. The predicted water elevations and depth mean velocities have compared favorably with field measurements taken at four specific sites along the estuary, which would suggest that the technique is an improvement on an earlier scheme that gave unstable results for the Humber Estuary. (16 refs)

Falconer, R. A., Wolanski, E., and Mardapitta-Hadjipandeli, L. 1986. Modeling tidal circulation in an island's wake. *Journal of Waterway, Port,*

Coastal and Ocean Engineering, ASCE, 112(2):234-254. Discussion by Lance Bode (6 refs), closure by R. A. Falconer, E. Wolanski, and L. Mardapitta-Hadjipandeli (5 refs), and errata, 114(1):104-110.

Details of a numerical model study to predict the tidal circulation observed and measured in the lee of Rattray Island, Australia, are presented. The hydrodynamic model is of the two-dimensional depth-integrated type, with particular emphasis being placed on the modeling of the advective accelerations and the lateral mixing in the free shear layer in the island's wake. the component of free shear layer turbulence includes a constant eddy viscosity approach in the mixing zone and the use of a semiempirical lateral velocity distribution. The numerically predicted circulatory velocity fields have been compared with field measurements, taken at 26 sites, aerial observations, and Landsat imagery. The comparisons between both predicted and measured results are encouraging, with the eddy dimensions and circulation strength being similar for all tidal phases. Various other simulations are described which chiefly suggest that for this study, (a) the eddy characteristics are reduced when the lateral shear stress is neglected; (b) no eddy is reproduced when the advective accelerations are excluded; (c) bathymetric effects are significant; and (d) geostrophic effects are important at water elevation boundaries. (26 refs)

Fandry, C. B., Hubbert, G. D., and McIntosh, P. C. 1985. Comparison of predictions of a numerical model and observations of tides in Bass Strait. *Australian Journal of Marine and Freshwater Research* 36(6):737-752.

A depth-averaged numerical model is used to describe the tidal regime in Bass Strait. Tidal constants corresponding to the four major tidal constituents M_2, S_2, 0_1, and K_1) are calculated at the grid points of the model, and co-amplitude and co-phase contours are drawn for each of the constituents. At 17 locations in Bass Strait, the computed tidal constants are in excellent agreement with those obtained from flow and sea level data. the dominant tidal constituent is found to be the semidiurnal, M_2, tide, which is predicted by the model with an accuracy of 10 percent in sea level amplitude and 10 deg in phase. The M_2 tide in Bass Strait is generated by two oppositely travelling waves, one entering the eastern end and another entering the western end with a phase lag of about 3 hr. Some amplification of these waves occurs as they move from the deep water into the much shallower continental shelf waters of the strait, and their superposition causes a large tidal amplitude (up to 1.2 m) to occur in central Bass Strait. The other three constituents are much weaker than the M_2 constituent, and are driven by tidal waves entering from the western end. They propagate eastward, emerging at the eastern end with little change in amplitude throughout the strait. (16 refs)

Fields, M. L., Weishar, L. L., and Clausner, J. E. 1988. Analysis of sediment transport in the Brazos River diversion channel entrance region. (See complete entry in Section II.)

†Filadelfo, R. J. 1984. Subtidal sea level and current variability in the Hudson Raritan Estuary. Ph.D. diss., State University of New York at Stony Brook.

The response of subtidal sea level and currents within the Hudson Raritan Estuary to coastal sea level, local wind, and riverine forcing is examined. The system forms a complex branched estuarine network more representative of a system of coupled basins than a classical estuary. Frequency domain regression is applied to sea level and current velocity time series from the 1980-81 National Ocean Service Circulatory Survey within the estuary. Response functions are interpreted in light of simple dynamic models. Results suggest very strong coupling between the estuary and the New York Bight. The response of barotropic flow through the East River to coastal sea level and local wind forcing is complex; coastal sea level dominates at periods longer than approximately 7 days and local wind setup dominates at shorter periods. A simple model is outlined which could be used to study subtidal response in shallow coupled basins subject to local wind and boundary sea level forcing.

†Fisher, C. W. 1986. Tidal circulation in Chesapeake Bay. Ph.D. diss., Old Dominion University, Norfolk, VA.

This study is a comprehensive examination of the tidal circulation of Chesapeake Bay and its major tributaries. Tide and current data, which were observed in Chesapeake Bay by the National Ocean Service during the period from 1972 to 1983, are analyzed and used to construct charts that describe the tide and tidal current. Fractionally damped analytic models are used to explain the tidal hydrodynamics of the observed tides, determine the location of the quasi-nodes and antinodes of the M_2 and K_1 tidal waves, explain the relationship of the tides and tidal currents, and determine if the tide in lower Chesapeake Bay is a Kelvin wave with an

amphidromic pattern of cotidal lines. The amplification of constituents as the tide circulates throughout the bay and tributaries is also described and explained. Tide data from 108 locations throughout the bay and major tributaries and current meter data from 124 locations in the bay have been analyzed using nonharmonic and harmonic analysis techniques. Cotidal and corange charts have been constructed based on the results of the nonharmonic analysis. Comparable coamplitude and cophase charts for the M_2 and K_1 tidal constituents have been constructed using the harmonic constraints determined during the study. Similarly, the harmonic constants for the M_2 tidal current constituent are used to construct cophase and cospeed charts which serve as an approximate description of the tidal current at maximum flood. A one-dimensional analytic model of a fractionally damped reflected tidal wave is used to determine whether reflection actually occurs in each basin, where it occurs, and how much the tide is attenuated. Frictional damping coefficients ranging from 2.1 to 3.0 have been determined for the major tributaries and upper bay. It is shown that the tide in the lower bay cannot be modeled properly using a one-dimensional analytic model because of its width. A two-dimensional analytic model of a reflected Kelvin wave is considered. This model, as well as the charts constructed during this study, indicates the tidal circulation in the lower bay may be an amphidromic system with a virtual amphidrome located onshore to the west of the bay. The amplification of shallow-water constituents is observed to be fairly large near the limit of tide in the major tributaries, but is relatively insignificant elsewhere. This amplification has been shown to be caused by the nonlinear effect of friction on the tide.

Fleming, C. A., and Simpson, J. 1986. Studies for and design of dredging and reclamation for a new port. (See complete entry in Section V.)

Forbes, A. M. G., and Church, J. A. 1983. Circulation in the Gulf of Carpentaria: II, Residual currents and mean sea level. (See complete entry in Section I.)

Fornerino, M., and Le Provost, C. 1985. A model for prediction of the tidal current in the English Channel. *The International Hydrographic Review* 62(2):143-166.

A model for prediction of tidal currents in the English Channel is presented. It is based on the classical harmonic description of tides deduced from the spectral development of the luni-solar tidal potential. The spatial distribution of the characteristic parameters (intensity, phase, and direction of the maximum velocity vector, ellipticity of the hodograph) for the 26 harmonic constituents introduced in the prediction procedure are deduced from a numerical simulation of 1 month's duration for the entire English Channel. Two kinds of documents can be produced from this model: instantaneous velocity fields over a given area, and time series of the intensity and the direction of the velocity vector at a given location, over a given period. Four examples of prediction are presented, corresponding to specific areas and over periods where tidal currents have actually been observed. The comparison between predictions and observations is very satisfactory. (11 refs)

Friedrichs, C. T., and Aubrey, D. G. 1988. Nonlinear tidal distortion in shallow well-mixed estuaries: A synthesis. (See complete entry in Section VIII.)

Furumai, H., Kawasaki, T., Futawatari, T., and Kusuda, T. 1988. Effect of salinity on nitrification in a tidal river. (See complete entry in Section III.)

Futawatari, T., Kusuda, T., Koga, K., Araki, H., Umita, T., and Furumoto, K. 1988. Development of a new simulation method for suspended sediment transport in a tidal river. *Water Science and Technology* 20(6/7):103-112.

A one-dimensional simulation model of suspended sediment transport in a tidal river was developed with erosion, deposition, and thickening processes of sediments, and inflow from tributaries. This model uses the explicit leap-frog method, and its lower end boundary of the river is extended into the sea to close the boundary for calculation. Laboratory experiments were performed to determine erosional and depositional rates of sediments and to study the sediment thickening process in the river under various concentrations of chlorinity and suspended solids. Numerical simulation results with the parameter values obtained experimentally did not show good agreement with observed data. Modifying the parameter values according to physical phenomena was necessary to obtain good agreement in between. After the modification, computation results during a fortnightly cycle explain satisfactorily the sediment transport phenomena in this river. (3 refs)

Gade, H. G., Edwards, A., and Svendsen, H., eds. 1983. *Coastal oceanography.* (See complete entry in Section I.)

Gaillard, T. R. M. G., and Huizinga, P. 1988. Hydraulic model study of the Kariega and Great Fish estuaries. CSIR Technical Report EMA-T 8801. Stellenbosch, South Africa: Division of Earth Marine and Atmospheric Science and Technology, Council for Scientific and Industrial Research.

The application of the CSIR's one-dimensional hydrodynamic estuary model to the Kariega and Great Fish estuaries is described in this report. Excellent calibration results were achieved for the Kariega Estuary while only a reasonably calibrated model could be established for the Great Fish Estuary, which was not fully covered by survey work. (3 refs)

†**Gardner, G. B.** 1984. Internal hydraulics and mixing in highly stratified estuaries. (See complete entry in Section III.)

Garvine, R. W. 1987. Estuary plumes and fronts in shelf waters: A layer model. (See complete entry in Section I.)

Gascoine, I. S., and Jury, K. M. 1984. The development and use of a theoretical mathematical model for the Medway Estuary. *Water Pollution Control* 83(1):31-41.

In 1976 a Subgroup of the Medway Resources Working Group was set up to investigate reducing the residual flow of fresh water into the Medway Estuary. The abstraction of additional water from the nontidal section of the River Medway was one option under active consideration for supplying future needs for water supply in north and mid-Kent, and it was known from an earlier study that this could result in the deterioration of the quality of water in the upper estuary under certain conditions. A theoretical model was constructed to examine the physical, biological, and chemical changes occurring within the estuary and was to be used as an instrument to enable the prediction of water quality (dissolved oxygen and chloride) resulting from changes in natural and imposed conditions. The natural condition variables examined were freshwater flow, tidal height, meteorological conditions, mud respiration, and photosynthesis. Imposed conditions were the effluent conditions necessary to achieve the water quality criteria together with the discharge of effluent related to tide, discharging effluent further down the estuary, seawater recirculation, and artificial reaeration. (7 refs)

Gelfenbaum, G. 1983. Suspended-sediment response to semidiurnal and fortnightly tidal variations in a mesotidal estuary: Columbia River, U.S.A. (See complete entry in Section II.)

Gerritsen, F. 1985. Tidal hydraulics - Historic perspective and future trends in engineering analysis. (See complete entry in Section I.)

†**Geyer, W. R.** 1985. The time-dependent dynamics of a salt wedge. Ph.D. diss., University of Washington, Seattle.

The time variations of the salt wedge intrusion in the Fraser Estuary, British Columbia, were monitored under a variety of tidal and runoff conditions, using instruments and sampling methods that provided high resolution of the velocity and water properties in space and time. The salt wedge was found to vary considerably in position and vertical structure through the tidal cycle due to interaction of the tidal flow with the baroclinic dynamics of the salt wedge. During the flood, the salt wedge progressed up the estuary as a gravity current, the structure and propagation characteristics of which were significantly influenced by the presence of the bottom boundary layer. The propagation characteristics of the salt wedge were modelled by extending existing gravity current theory to include bottom stress. This model was then incorporated as the landward boundary condition for a finite-difference, time-dependent, two-layer representation of the estuary, designed to simulate the essential features of the baroclinic dynamics during the flood phase of the tide. The hybrid analytical/numerical model closely matched the observed propagation speed of the front of the salt wedge throughout its advance, as well as reproducing the major variations in interfacial structure. Unlike the flood conditions, the ebb flow results in pronounced vertical mixing across the pycnocline, leading to collapse of the salt wedge intrusion. In traction of the barotropic and baroclinic flows produces strong vertical shear during the ebb, leading to shear instability within the pycnocline. Direct observations of instabilities with a high-frequency echo sounder indicate that a stability threshold based on the mean Richardson number is not appropriate, due to the destabilizing influence of internal wave shears. A modified Richardson number *Ri* is defined, which includes wave-generated as well as mean shear. The stability threshold is found to be $Ri = 0.25$, as in linear stability theory.

†**Goodrich, D. M.** 1985. On stratification and wind-induced mixing in the Chesapeake Bay. (See complete entry in Section III.)

Gotlib, V. Y., and Kagan, B. A. 1985. A reconstruction of the tides in the paleocean: Results of a numerical simulation. (See complete entry in Section I.)

Graham, D. S., and Mehta, A. J. 1981. Burial design criteria for tidal flow crossings. *Transportation Engineering Journal of ASCE* 107(TE2):227-242.

Design criteria for burial depths (for submarine pipelines, cables, diffusors, etc.) across tidal rivers, estuaries, and inlets are examined. For the case of shallow, alluvial tidal rivers and estuaries, design computation based upon real-time records is suggested. Numerical hydrodynamic models may be used to find the instantaneous flow depths and velocities. The corresponding tractive stresses can then be computed for peak velocities by assuming a logarithmic velocity distribution. For tidal inlets, additional considerations must be given to the effects of waves on sediment transport near the seaward end of the inlet. A relationship for predicting the maximum scour depth in a new inlet as a function of the spring tidal prism is proposed. For inlets that are to be modified, the expected change in the maximum depth due to a change in the tidal prism can be computed. (34 refs)

Granat, M. A., Brogdon, N. J., Cartwright, J. T., and McAnally, W. H., Jr. 1989. Verification of the hydrodynamic and sediment transport hybrid modeling system for Cumberland Sound and Kings Bay navigation channel, Georgia. Technical Report HL-89-14. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

A hybrid modeling system (coupled physical and numerical models) was developed to investigate the hydrodynamic and sedimentation processes of Cumberland Sound and the interior Kings Bay navigation channel. The hybrid modeling procedures and the physical and numerical model verifications are described in detail. The Kings Bay physical model was an accurately scaled fixed-bed concrete model of the Cumberland Sound/Kings Bay estuarine system. The physical model provided the means of assessing three-dimensional hydrodynamic characteristics of Cumberland Sound and Kings Bay. It also provided the boundary forcing conditions for the numerical model and an expanded data base for comparison. Verification of the physical model to reproduce preconditions measured during January 1985 was demonstrated. The other component of the modeling system was the US Army Corps of Engineers Generalized Computer Program System: Open-Channel Flow and Sedimentation, TABS-2. TABS-2 is a complete depth-averaged finite element numerical modeling system. The numerical hydrodynamic model RMA-2V used physical model-derived St. Marys Inlet water levels and tributary velocity measurements for the boundary forcing conditions for an average tidal cycle. The numerical model was verified to physical model tidal elevations and depth-averaged velocity data for interior locations. A wetting and drying algorithm was used to numerically model the extensive marsh and intertidal areas of the estuarine system. Marsh-estuarine circulation interaction and prescribed marsh elevation were found to be important in achieving proper hydrodynamic reproduction. Three separate numerical model evolved in detail. RMA-2V demonstrated reasonable reproduction of pre-Trident and transitional channel hydrodynamic conditions for the Cumberland Sound/Kings Bay system. Hydrodynamic results from RMA-2V were used in the numerical sediment transport code STUDH in modeling the interaction of the flow transport and sedimentation on the bed. Both cohesive (clay and silt) and noncohesive (silt and sand) sedimentation were modeled. STUDH was verified through comparisons of model predictions with actual field shoaling rates. Excellent numerical model pre-Trident channel sediment verification was demonstrates. Excellent numerical model pre-Trident channel sediment verification was demonstrated. Model predictions for the upper Trident channel turning basin for the transitional channel demonstrated higher shoaling rates than the limited field data. Possible explanations for this difference included low field sediment loads associated with the prolonged east coast drought, the transitional nature of the channel, and the possible need for further model adjustments. The sediment model was developed and verified for long-term average conditions, and additional model adjustments could not be justified based on the limited transitional channel data. Verification of the hydrodynamic and sediment transport hybrid modeling system for Cumberland Sound and Kings Bay navigation channel has been demonstrated. The developed modeling procedures can be used in carefully designed testing programs to assess potential hydrodynamic and sedimentation impacts associated with submarine plan channel and remedial measure alternatives. (16 refs)

Granat, M. A., Gulbrandsen, L. F., and Pankow, V. R. 1985. Reverification of the Chesapeake Bay

model; Cheseapeake Bay hydraulic model investigation. (See complete entry in Section I.)

Gray, W. G., and Kinnmark, I. P. E. 1983. QUIET: A reduced noise finite element model for tidal circulation. *Advances in Engineering Software* 5(3):130-136.

The model described uses the vertically averaged wave equation and momentum equations to simulate two-dimensional tidal flow. The model uses quadratic isoparametric elements in space and a new explicit (in time) scheme to compute surface elevations and velocities which are essentially noise free. The model is shown to be efficient in that it requires the solution of no matrices. A sample application to the southern North Sea demonstrates the utility of the model.

Greenberg, D. A. 1987. Modeling tidal power. *Scientific American* 257(5):128-131.

The famous tidal surges in the Bay of Fundy that sometimes send tourists running for their lives have long held the potential of economic power generation. Computer modeling of the bay and the Gulf of Maine enables planners and environmentalists to gage what the impact of a tidal power installation might be as far away as Boston Harbor.

Griffiths, D. K., Pingree, R. D., and Sinclair, M. 1981. Summer tidal fronts in the near-Arctic regions of Foxe Basin and Hudson Bay. *Deep-Sea Research* 28A(8):865-873.

A two-dimensional numerical model of the M_2 tide in Ungava Bay, Hudson Strait, Hudson Bay, and Foxe Basin is used to predict the possible mean positions of tidal fronts. These frontal regions separate areas of vertical tidal mixing from areas of summer stratification and mark possible regions of locally increased biological productivity. (13 refs)

†**Gross, T. F.** 1984. Tidal time dependence of geophysical turbulent boundary layers. (See complete entry in Section I.)

Guymer, I., and West, J. R. 1988. The determination of estuarine diffusion coefficients using a fluorimetric dye tracing technique. (See complete entry in Section VIII.)

Halliwell, A. R. 1986. Engineering model for well-mixed tidal basin. *Journal of Waterway, Port, Coastal and Ocean Engineering* ASCE, 112(5):572-590.

A simple representation for a tidal basin with fresh-water input is described. By assuming the conditions are well-mixed within the basin, it is possible to develop an elementary analysis for predicting salinities in the basin and sediment transport between the estuary and the basin due to density exchange flow. The results of the analysis are presented in a generalized manner, and this enables first estimates for some prototype situations to be made easily and with a minimal amount of field data. Some very simple physical model tests, described in the paper, have confirmed the validity of the analysis. An example of the use of the engineering model is given in which the dredging requirement at a small dock system is examined; this reveals some interesting and important features, and it is likely that these features apply at other tidal basins. (7 refs)

Hamm, L. 1986. Analysis of the evolution of beds in the Seine Estuary (Analyse de l'evolution des fonds dans l'estuaire de la Seine). *Bulletin of the Permanent International Association of Navigation Congresses* 53:3-15. (In French).

Development of the Seine Estuary over the past 30 years has involved in-depth studies and the construction of major works. The aim of development is to increase the draft of the access channel to the port of Rouen without calling for excessive dredging work. The draft was increased from 7 m in 1955 to 10.7 m in 1982. In order to study and design the development works, a mobile-bed scale model and mathematical model simulating tide propagation were used. In this way it was possible to predict variations in the channel elevation, depths in other parts of he estuary, and the dredging work required for maintaining the channel. New studies aimed at minimizing maintenance dredging and optimizing the use of dredging equipment were undertaken, involving the use of a descriptive statistical model to give a clearer picture of the natura phenomena. Major investigation equipment was installed by the Rouen Port Authority in order to monitor changes in the estuary following construction of the new works. Analysis of the data obtained shows that the forecasts made during the studies have generally proved to be satisfactory. These involved only mean values in space and time. Greater knowledge is now required of the phenomena involved, particularly in regard to short- and medium-term forecasts. For this, measuring techniques and descriptive models must be

developed. This article briefly summarizes the studies and works already carried out and described in detail by Parthiot. It then gives a description of the new tool used and the initial results obtained. Discrepancies have nevertheless been observed locally between the observed sediment input and that predicted by the model. The extensive data available made it possible to look for correlations between the fluctuating bed elevations of the navigation channel and the various natural factors: wind, tides, and Seine discharge. To this effect the navigation channel was divided into 18 sections each 1 km long. For each bathymetric survey available (between 1981 and 1983) a mean bed elevation of each section was calculated. Then the volume of erosion or deposition between two successive surveys was calculated, and a correlation was sought between this result and the effects of tides, wind, and Seine discharge during the period considered. This analysis showed in particular a correlation between the effect of westerly winds and deposits located in the area of the breach, as well as a certain modulation of the effect of the Seine discharge between the upstream and downstream limits. The variations in bed elevation and the dredging works undertaken are presented for three sections. These sections are representative of the downstream, middle, and upstream parts of the estuary. Variations of natural factors over the same period are presented. The results obtained are relatively modest. Nevertheless, now that the means necessary for collection and processing of the data required for finer analysis of sedimentary mechanisms have been established, it will be possible to start a new study phase using a correlation model with a Kalman filter. (3 refs)

Hamm, L., Barailler, L., Rambaud, B., and Hauville, S. 1986. Analysis of sediment load in the navigation channel of the Seine Estuary. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:559-568. University, MS: University of Mississippi.

Development of the Seine Estuary over the past 30 years has involved in-depth studies and the construction of major works. The aim of development is to increase the draft of the access channel to the Port of Rouen without calling for excessive dredging work. The draft was increased from 7 m in 1955 to 10.7 m in 1982. In order to study and design the development works, a mobile-bed scale model and mathematical model simulating tide propagation were used. In this way it was possible to predict variations in the channel elevation, depths in other parts of the estuary, and the dredging work required for maintaining the channel. This article briefly summarizes the studies and works already carried out and described in detail by Parthiot. A description of the new tool used and the initial results obtained are given. (3 refs)

Hamm, L., Quetin, B., and Usseglio-Polatera, J. M. 1985. Two-dimensional modelling of wind-induced currents in coastal and harbour area. In *International conference on numerical and hydraulic modelling of ports and harbours,* 23-25 April 1985, Birmingham, England, ed. J. H. Pounsford, 13-22. Cranfield, Bedford, England: BHRA, The Fluid Engineering Centre.

For wind-induced currents computation, the generally used approach consists in applying tangential wind stress to the free surface and using two-dimensional (Sd) tidal equations. The influence of the third dimension upon the horizontal current fields can be taken into account with formulas obtained from vertical models to turbulence due to wind action. The paper describes the formulas obtained and their application in the CYTHERE ES1 2D tidal flow modelling system. The differences between the classical (through tangential stresses only) and the new approach will be given and shown in application examples. The problems arising at the model boundaries because of wind action are described. Through numerical computation the effects of variations of bottom topography upon the wind-induced horizontal circulation in nearly closed shallow coastal areas are shown. (7 refs)

Han, Z., and Cheng, H. 1986. Two-dimensional sediment mathematical model of Hangzhou Bay. In *River Sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:463-471. University, MS: University of Mississippi.

In the planning of projects of navigation, reclamation, water conservancy, and tidal power development in estuarine and coastal regions, prediction of riverbed deformation should be made. Calibration at five tidal gages, nine verticals of depth-averaged velocity, and sediment concentration in the studied water region were carried out. The discrepancies between the calculated and observed values of the total volume of flows and sediment transport per unit width with flood flow and ebb flow were less than 20 percent and 30 percent, respectively. This is

comparable to the accuracy in field measurement. By using the moving boundary method, the simulation of the water level and velocity on the tidal flat was carried out. Based on the simulation of tidal level, velocity, and sediment concentration, the regions of both erosion and deposition were computed and agreed with the natural situations. (6 refs)

Hao-Lin, L. 1986. Numerical computation for two-dimensional riverbed deformation in estuaries. In *River sedimentation*, Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:344-353. University, MS: University of Mississippi.

On the basis of basic equations for two-dimensional tidal flow and sediment, a mathematical model for two-dimensional tidal flow velocity field and riverbed deformation was established by using an element integration method. This method can be used to compute variation processes of the two-dimensional flow velocity field and sediment concentration as well as plane distribution of scour and silt quantities in a reach. The computations were verified by the data surveyed in Yangfushan reach, Oujiang Estuary. (6 refs)

†**Hayter, E. J.** 1983. Prediction of cohesive sediment movement in estuarial waters. Ph.D. diss., University of Florida, Gainesville.

Fine sediment related problems in estuaries include shoaling in navigable waterways and water pollution. A two-dimensional (horizontal), fine cohesive sediment transport model using the finite element method has been developed to predict the temporal and spatial variations of the depth-averaged suspended sediment concentrations in estuarial waters. The advection-dispersion equation with appropriate source/sink terms is solved by the Galerkin weighted residual method for the suspension concentration at each node. Contemporary laboratory and field evidence has been used to develop algorithms which describe the processes of erosion, dispersion, settling, deposition, bed formation, and bed consolidation. The model yields stable and converging solutions. A useful feature of the model is its ability to predict the influence of salinity on the rate of fine suspended sediment movement. Verification was carried out against results from a series of erosion-deposition experiments in the laboratory using kaolinite and a natural mud as the sediments. The model was applied under prototype conditions to simulate sedimentation in a marina basin and suspended sediment transport in a hypothetical canal in which both erosion and deposition occurred.

†**Hayward, D. M.** 1986. Contribution to the hydrobiology of the York River: Predicting surface mixed layer depth. (See complete entry in Section III.)

Healy, T., Black, K., and de Lange, W. P. 1985. Numerical model field requirements for detailed simulation of currents and sediment transport in large tidal-inlet harbours. In 1985 *Australiasian conference on coastal and ocean engineering,* 2-6 December 1985, Christchurch, New Zealand, 2:475-484. Barton, A.C.T., Australia: The Institution of Engineers, Australia.

Recent large-scale harbor development proposals have resulted in the application of two-dimensional numerical models at Whangarei (new timber port) and Taurange (harbor bridge and dredging), both of which are meso-tidal inlets in northeast New Zealand. The problems investigated were development-induced changes to the sedimentation regime. Solutions provided by the numerical modelling included not only assessment of the impact of planned harbor works, but were also utilized at the design stage to minimize the future effect of the proposed works on the harbor environment. Because of the scope of the undertaking and the requirement of a high level of reliability, such sophisticated models depend on an extensive field investigation program. Confidence in the model output depends essentially on the quality, diversity, and coverage of the field data, which includes modern accurate hydrographic surveys and accurate tide gage data at several locations, especially near the model grid boundaries. Both vertical velocity profile measurements over full tidal cycles and continuous recording current meter records are required for calibration and verification of the hydrodynamic models. Suspended sediment sampling is needed for the sediment transport modelling. Side-scan sonar surveys, with extensive bottom sediment sampling and analysis, underwater photography, and underwater video records provide essential information for input into the sediment transport model. In addition, these data build up an imagery of the sea floor active sediment and ecological zones, and allow good inference on likely sediment transport model. In addition, these data build up an imagery of the sea floor active sediment and ecological zones, and allow good inference on likely sediment transport patterns and potential ecological damage. Further useful information is derived from bed-load sediment trapping, color air photography, historical air photographs, and

historical hydrographic surveys. The potential to undertake such widely embracing investigations has been developed only recently in New Zealand. (13 refs)

Hearn, C. J. 1985. On the value of the mixing efficiency in the Simpson-Hunter h/u^3 criterion. (See complete entry in Section I.)

Hearn, C. J., and Pearce, A. F. 1985. NOAA satellite and airborne sensing of a small-scale, coastal tidal jet. (See complete entry in Section I.)

Hearn, C. J., Hunter, J. R., Imberger, J., and van Senden, D. 1985. Tidally induced jet in Koombana Bay, Western Australia. *Australian Journal of Marine and Freshwater Research* 36(4):453-479.

A study is made of a coastal tidal jet, based on a field program together with numerical and analytical modelling of the tidal discharge and jet dynamics. A new criterion is demonstrated for bottom attachment of low-aspect-ratio buoyant jets. The slightly buoyant jet is attached to the seabed over the initial 2 km of its trajectory, which lies in shallow coastal waters of less than 10-m depth. The jet is about 200 m in width, and so its ratio of depth to half-width (aspect ratio)) is much lower than for previously reported bottom-attached jets. The longitudinal retardation of the axial speed of the jet is due to bottom friction and entrainment. The jet widens only slowly with distance along its trajectory because entrainment is limited to its sides and is compensated by bathymetric deepening. The jet attaches to the coastline by turning, without loss of speed, to move parallel to the shore. The coastal attachment width is found to be a simple function of the ratio of the jet discharge velocity to the speed of the prevailing alongshore current. (25 refs)

Heath, R. A. 1981. Resonant period and Q of the Celtic Sea and Bristol Channel. *Estuarine, Coastal and Shelf Science* 12(3):291-301.

A simple linear resonant response model fitted to the semidiurnal tidal constituents in the Celtic Sea given estimates of the resonant period of 10.8 to 11.1 hr with values of Q of about 3. The resonant period of the Bristol Channel is well below that of the semidiurnal tidal band making estimates of the resonant period and Q less reliable. Estimates based on data near the entrance to the Bristol Channel give periods of 7.3 to 9 hr, the lower values of 7.3 hr with a Q of between 6 and 9 being probably the best estimate. (11 refs)

Heath, R. A. 1981. Variations of the semi-diurnal tidal admittance near New Zealand. (See complete entry in Section I.)

Heathershaw, A. D., and Codd, J. M. 1985. Sandwaves, internal waves and sediment mobility at the shelf-edge in the Celtic Sea. (See complete entry in Section II.)

Henriques, A. G. 1986. Mathematical model for unsteady flow and sediment routing in estuaries. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:412-420. University, MS: University of Mississippi.

A mathematical model for computing unsteady flow, sediment routing, and bed profile evolution of estuaries and river reaches subject to tidal influence is presented. The simulation of large-scale hydrodynamics of estuaries is based on the one-dimensional set of the Saint Venant equations, taking into account the effect of bed forms on flow roughness. The computation of the evolution of bed profile is based on a continuity equation for sediment discharge, and a sediment transport equation. (11 refs)

Herbertson, P. W. 1982. Salinity and resource development problems in East Kent. (See complete entry in Section III.)

Hinwood, J. B. 1979. Hydrodynamic and transport models of Western Port, Victoria. *Marine Geology* 30(1/2):117-130.

As a part of the Western Port Bay Environmental Study, several numerical models of water quality and chemical transports have been developed. The Hydrodynamic Model includes the effects of wind stress, bed shear stress, Coriolis force, local and advective accelerations, and water surface slope. The model consists of a finite-difference scheme for solving the depth-averaged hydrodynamic equations in two dimensions. The output consists of arrays of tide height and two horizontal velocity components at each grid point and computational time step. The Pollutant Transport Model uses Elder's equations for longitudinal and transverse dispersion in an open channel. The trajectories of computational particles of water carrying pollutants and other materials are calculated at successive times as they are moved by the currents and as they are spread by the action of turbulence and nonuniformities in the velocity profile. This model treats the nonreactive or

conservative materials in the water. The Chemical Kinetics and Interaction Model, which is run jointly with the Pollutant Transport Model, simulates the behaviour of nonconservative and interacting materials. Quantities modelled are heat content, organic carbon, dissolved oxygen, nitrogen in its various forms, suspended sediment discharges, coliform bacteria, and any exponentially decaying materials. The model computes concentrations of materials at the various grid points and time steps. The Hydrodynamic and Pollutant Transport Models have been run for an average tide (the M_2 component) and a sequence of spring tides. Computed half-tidal fluxes across seven sections dividing the major segments of the bay compared favorably with measured values. A detailed comparison of depth-averaged velocities was also made at the seven sections. These models have been used to predict the patterns of water movement in the bay and to interpret observations made in some of the other studies. (11 refs)

Hinwood, J. B., and Jones, J. C. E. 1979. Hydrodynamic data for Western Port, Victoria. (See complete entry in Section VIII.)

†Hires, R. I., Oey, L.-Y., and Mellor, G. L. 1983. Prediction of oil spill trajectories in New York Harbor. (See complete entry in Section IV.)

Holly, F. M., Jr., and Usseglio-Poletera, J.-M. 1984. Dispersion simulation in two-dimensional tidal flow. (See complete entry in Section IV.)

Holz, K.-P., and Heyer, H. 1986. Control of sediment transport in a tidal river. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:100-109. University, MS: University of Mississippi.

This paper reports an attempt to control the gates of a storm surge barrage in a tidal river in such a way that the observed intrusion of sediment can be minimized or the process of intrusion even reversed. The investigation is performed on the basis of a one-dimensional numerical river model, which simulates the hydrodynamics of the Eider estuary, for which an application is made. (7 refs)

Horie, T. 1988. The role of modelling in the control of seawater pollution. *Water Science and Technology* 20(6/7):277-286.

A feasibility study of seawater improvement projects in selected bays where seawater is highly polluted by organic substances is being conducted. They study includes field surveys in these bays of, for example, seawater quality, sediment characteristics, sediment release rate, sediment settling rate, organism growth rates, and biological activity. Numerical analysis of the situation is also being conducted, using a set of mathematical models. A water quality prediction model was formulated on the basis of phosphorus cycling between seawater, phytoplankton, and sediment. The results of the simulation predicted that the effect of seawater quality improvement would be unexpectedly small, because of dilution due to advection and dispersion by seawater circulation. However, in the field, ecological conditions seem to be significantly improved, given that the number of benthic species and the populations of these species increase on treated sediment, even though the improvement of water quality is less than expected. Based on these results, the author discusses the role of the numerical model and gives examples of its application in predicting the environmental improvement due to seawater quality improvement. (5 refs)

Houston, J. R., Vemulakonda, S. R., Scheffner, N. W., and Ebersole, B. A. 1986. Coastal and inlet processes (CIP) numerical modeling system. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:93-99. University, MS: University of Mississippi.

A group of system of numerical models is described that calculates waves, currents, and sediment transport in coastal areas including very complex inlets. All models use the same variable spacing finite difference grid that concentrates grid cells in surf zone and inlet areas. Tidal and wind-driven currents are determined in the system using the well-known US Army Engineer Waterways Experiment Station's (WES) Implicit Flooding Model (WIFM). Waves are calculated using a model which calculates combined refraction and diffraction. A wave-induced current (littoral and rip current) model based upon WIFM calculates currents and setup due to forcing by radiation stresses. A sediment transport model component determines transport of sand by waves and currents. The CIP modelling system was originally developed to study a variety of coastal processes at Oregon Inlet, North Carolina. The model has recently been used to study expected channel shoaling at the St. Marys Inlet entrance to

Kings Bay Naval Base. Applications of the modelling system to study channel shoaling, dredged material disposal, and the interaction of waves with the complex bathymetry and currents of an inlet are presented. (24 refs)

Huang, Z., Yuan, X., Chen, S., and Qin, H. 1986. The experimental investigation for the improvement of Modaomen Outlet of the Pearl River Estuary in China. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:542-551. University, MS: University of Mississippi.

The Pearl River is the largest river in south China. Modaomen is the main outlet of the Pearl River Estuary. For a long time, the water level along the river reach upstream has been raised continually because of the shoaling and extension of the estuary. The irrigation and drainage conditions have deteriorated, and the depth of the Hongwan navigational channel has been reduced gradually. In order to improve the Pearl River Estuary in a planned way to overcome the unfavorable effects due to natural extension of the estuary and to develop the beach land resources comprehensively, hydraulic model tests of Modaomen, outlet of the Pearl River Estuary, were conducted. (1 ref)

Huizinga, P. 1985. A dynamic one-dimensional water quality model. CSIR Research Report 562. Stellenbosch, South Africa: National Research Institute for Oceanology, Council for Scientific and Industrial Research.

Urban and industrial development is taking place around many estuaries in South Africa. As a consequence such actions as the release of domestic and industrial wastes into these estuaries or the reduction of freshwater inflow often strongly affect their ecologies. Difficulty has been experienced in the prediction of the quantitative impact of these wastes on the water quality of the estuary as a whole. To overcome this problem the one-dimensional dynamic water quality model presented in this report has been developed as a means of predicting transport and concentrations of pollutants or other constituents (for example, salinities) in estuaries. It can be operated at relatively low cost (a few hundred Rand) for long prototype periods (months). It is operated in conjunction with a one-dimensional hydrodynamic model. Phenomena such as spring-neap-spring tidal variations, river floods, and evaporation, which sometimes have considerable influence on the water quality, can all be taken into account. (6 refs)

Huizinga, P. 1984. Application of the Nrio 1-D hydrodynamic model to the Swartkops Estuary. CSIR Research Report 560. Stellenbosch, South Africa: National Research Institute for Oceanology, Council for Scientific and Industrial Research.

To determine the performance of the model, it was applied to studies of the Swartkops River and estuary system. use of the model enabled a good understanding of the major hydrodynamics features of the estuary. This report describes the model simulations with the calibration data and presents a discussion of the results. Also described are runs of the model to determine the maximum flood levels for a 1:100-year flood in the estuary. (2 refs)

Huizinga, P. 1987. Hydrodynamic model studies of the Swartvlei Estuary. CSIR Report T/Sea 8709. Stellenbosch, South Africa: National Research Institute for Oceanology, Council for Scientific and Industrial Research.

This report describes an application of the National Research Institute for Oceanology's one-dimensional hydrodynamic model to the Swartvlei Estuary for the purpose of computing the inflow and outflow through the estuary mouth, which could be used to determine fluxes of materials. (4 refs)

Huizinga, P., and Gaillard, T. R. M. G. 1985. Documentation: One-dimensional hydrodynamic and water-quality model program. (See complete entry in Section VIII.)

Huizinga, P., and Haw, P. M. 1986. A mathematical transport-dispersion model of the Knysna Estuary. *The Civil Engineer in South Africa* 28(7):265-270.

To meet the ever-increasing demand for water, the possibility of extracting water from the Knysna River, upstream of the estuary, is under investigation. In this paper the results of simulations of the influence of freshwater inflow on the salinity distributions in the estuary, using a transport-dispersion model, are presented. The simulations also show the potential of the model which can easily be adapted for use on other estuaries. The mathematical transport-dispersion model was developed at the National Research Institute for Oceanology (NRIO) of the Council of Scientific and Industrial Research (CSIR). (5 refs)

Huizinga, P., and Smith, C. J. 1987. Computation of flow through the Palmiet Estuary mouth. CSIR Report T/SEA 8706. Stellenbosch, South Africa: National Research Institute for Oceanology, Council for Scientific and Industrial Research.

A routine is presented which can be used to compute flow through an estuary mouth, provided the estuary is short and certain information is available. An application of the routine to the Palmiet Estuary has given excellent results. These results can be very useful for further studies of the estuary. The simplicity of the routine and the usefulness of the results, which are clearly demonstrated in this report, make it particularly suitable for application to studies of other small estuaries where estimated estuary mouth fluxes form a vital part of the studies.

Huthnance, J. M. 1983. Simple models for Atlantic diurnal tides. *Deep-Sea Research* 30(1):15-29.

Gill's narrow-canal Atlantic-Southern Ocean model fails for diurnal tides. Suggested modifications are flow through the open end of the Atlantic at 60°N, a Southern Ocean "broad" for the coastal-trapped diurnal tide at high latitudes, and hence escape around South Africa of the southward-progressing component of the Atlantic tide (implying no resonances). Idealized models suggest that even the Drake Passage is "broad." The large Southern Ocean tide progresses westwards along the Antarctic coast, almost as though South America were absent, but a small part is diffracted northwards. The Atlantic tides are small and therefore relatively sensitive to the diffracted wave, to the different K_1 and O_1 natural wave-numbers, and to earth-tide effects. (21 refs)

Hydraulics Research Station. 1981. Severn tidal power. Wallingford, UK.

In the United Kingdom, the Department of Energy commissioned prefeasibility studies during 1978 to 1981 to examine the wide range of engineering, environmental, and economic implications of a tidal power scheme for the Severn Estuary. As part of these studies, the Hydraulics Research Station undertook a program of field, desk, and model investigations to assess the impact of a tidal power barrage on the hydraulics of the Estuary. A brief account of this research program is given which includes water movements, sediment transport, collection of field data, silt monitoring, properties of Severn Estuary mud, measurement of wave climate, and hindcasting extreme waves. (25 refs)

Imberger, J., Berman, T., Christian, R. R., Sherr, E. B., Whitney, D. E., Pomeroy, L. R., Wiegert, R. G., and Wiebe, W. J. 1983. The influence of water motion on the distribution and transport of materials in a salt marsh estuary. *Limnology and Oceanography* 28(2):201-214.

A formal approach is presented of ordering the time scales of the dominant fluxes of material in an estuary and then accordingly choosing the spatial and temporal resolution of the sampling program. In this way bounds can be derived for the internal turnover times, boundary exchange rates, and import or export fluxes of a particular substance purely from measurements of the standing stock values in the estuary water. Application of this methodology to an experiment in the Duplin River, Georgia, showed that if the effects of the water motion and mixing are extracted from the variation of a biological component, then the variability of the residual can be successfully interpreted. For a typical summer condition it was shown that ammonium was cycled rapidly within the marsh water, its distribution was very patchy, and only its decomposition products left the marsh; that the refractory dissolved organic carbon (DOC) component was steadily exported by longitudinal mixing while labile DOC was rapidly recycled in the water; that silicate was produced in large amounts in the marsh and exported by longitudinal mixing; that particulate organic carbon (POC) concentrations were almost completely determined by the turbulence intensity in the water; and that compared to this internal cycling, export was of minor significance. (28 refs)

Isaji, T., and Spaulding, M. L. 1987. A numerical model of the M_2 and K_1 tide in the northwestern Gulf of Alaska. *Journal of Physical Oceanography* 17(5):698-704.

A two-dimensional vertically averaged hydrodynamic model in spherical coordinates with 0.2° latitude, 0.35° longitude resolution was employed to predict the M_2 and K_1 tidal elevations and currents in the northwestern Gulf of Alaska, 50° - 168° W to the southern Alaskan coast. Boundary conditions for the model were derived from Schwiderski's global ocean tidal model and observations. Model predictions for the amplitude and phase of the sea elevations are generally within 5 cm and 2° of the observations for the M_2 constituent and 7 cm and 5° for the K_1. The M_2 standing was pattern in Shelikof Strait and the tidal resonance in Cook Inlet observed in earlier studies are confirmed by the numerical simulations. (16 refs)

†**Jamshidinia, H.** 1984. Development, verification and application of a two dimensional tidal hydrodynamics model for Barataria Bay. Ph.D. diss., Tulane University, New Orleans.

The development and application of a two-dimensional tidal hydrodynamics model which is capable of describing the velocity and salinity distribution for Barataria Bay are presented. The model is intended to be used in evaluating the effects of diversion of fresh water to Barataria Bay. The model has been verified and demonstrated in Barataria Bay for selected periods for which hydrologic and water quality data were available. In this study simulation of hydrodynamic and salinity response corresponding to a mean annual inflow, low flow and flood flow are provided. In these applications the effects of different dispersion coefficients, time-steps, and freshwater inflow upon velocity and salinity distribution are tested. In each run a comparison between computed and measured values is made.

Jiang, J. X., and Falconer, R. A. 1985. The influence of entrance conditions and longshore currents on tidal flushing and circulation in model rectangular harbours. In *International conference on numerical and hydraulic modelling of ports and harbours,* 23-25 April 1985, Birmingham, England, ed. J. H. Pounsford, 65-74. Cranfield, Bedford, England: BHRA, The Fluid Engineering Centre.

A series of hydraulic model tests is described. The effects of varying the entrance conditions for different tidal ranges and mean depths on the tidal flushing characteristics and circulation patterns in model rectangular harbors of various shapes are investigated with the models. The influence of longshore currents and the effects of vertical distortion on the mass exchange characteristics and velocity fields have been investigated for specific harbor shapes. The results of a simplified numerical model simulation are considered. In these simulations, however, the effects of wind action short-period waves, and the earth's rotation are excluded. (9 refs)

Jianghang, W., and Kaiqi, C. 1985. A hybrid method of fractional steps with L_∞-stability for numerical modelling of harbours and bays. In *International conference on numerical and hydraulic modelling of ports and harbours,* 23-25 April 1985, Birmingham, England, ed. J. H. Pounsford, 101-109. Cranfield, Bedford, England: BHRA, The Fluid Engineering Centre.

A new method for numerical modelling of harbors and bays is presented in this paper. It is based on a hybrid method of fractional steps using triangular grids and with L_∞ - stability. In this method a modified characteristics procedure is used for convection calculation, the lumping finite element technique for diffusion calculation, and a conservative difference scheme for wave propagation calculation. The temporal integration scheme is the explicit two-step scheme for momentum and concentration equations and the explicit one-step scheme for continuity equation. Stability analysis is described in detail. Proof is given that the scheme is L_∞-stable under the following conditions:

a. $\Delta t \leq \min \left[\frac{2d}{v} \cdot \frac{d^2}{3k}\right]$ where d = the minimum perpendicular length of all the triangles,

$v = \max \sqrt{v_x^2 + v_y^2}$, and k = diffusivity.

b. All the angles of triangles are less than or equal to $\frac{\pi}{2}$.

Meanwhile it is shown that the L_∞-stability implies the non-negativity of numerical solutions for the concentration or for the excess temperature. The convergence of this method for nonlinear problems has been tested using a one-dimensional nonlinear convective diffusion equation, together with the analytic solution. It can be concluded that the numerical damping effect in the computation is insignificant and that the numerical procedure is simple and stable. The method has been applied to Bohai Sea, including Liaodongwan Bay, Bohaiwan Bay, and Laizhouwan Bay, for analyzing the tidal exchange characteristics. (9 refs)

Johnson, B. H., Boyd, M. B., and Keulegan, G. H. 1987. A mathematical study of the impact on salinity intrusion of deepening the Lower Mississippi River navigation channel. Technical Report HL-87-1. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

One factor being considered in the evaluation of the feasibility of deeper draft access to the ports of New Orleans and Baton Rouge is the impact of a deeper channel on salinity intrusion in the Lower Mississippi River. To address this question, a laterally averaged mathematical model called LAEM that couples the flow and salinity computations through a baroclinic contribution to the longitudinal pressure gradient has been employed for 40-, 45-, 50- and 55-ft channels (with overdepth dredging) using historical low-flow

hydrographs. In addition, LAEM has been applied with increased heights of the natural river crossing at river mile 63.4 to determine if such sills provide an effective means of controlling salinity intrusion during critically low-flow periods. A separate question concerning the stability of such sills constructed from natural river sediment dredged from upstream has been addressed by applying the sediment transport model, HEC-6. General conclusions are that an increased channel depth up to 55 ft will result in significant increases in the extent and duration of salinity intrusion during extended low-flow periods. Sills constructed at a crossing by depositing materials dredged from upstream appear to provide an effective method for controlling the intrusion of the salt wedge, although tests on a sill at elevation -55 ft indicated the deposited material will be eroded away fairly quickly when the riverflow rises above 400,000 cfs. This will necessitate rebuilding the sill at the onset of each critically low-flow period expected on the Lower Mississippi River. (10 refs)

Johnson, B. H., Trawle, M. J., and Kee, P. G. 1986. Discussion of a laterally averaged numerical model for computing salinity and shoaling with an application to the Savannah Estuary. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:1443-1459. University, MS: University of Mississippi.

An existing laterally averaged estuary numerical model called LAEM has been modified to handle sediment computations along with flow, temperature, and salinity computations. A bed model that allows for multiple layers when the sediment is cohesive has been incorporated to simulate the exchange of sediment between the bed and the water column. The resulting model is called LAEMSED and should be a useful tool in assessing the impact of channel deepening on salinity intrusion and shoaling in either a single channel or a multiple-connected system of channels. Preliminary results from a study in the Savannah Estuary show excellent agreement with 1985 field data on tides, velocities, and salinities. In addition, good agreement with shoaling rates estimated from dredging records has been obtained in the navigation channel. (6 refs)

†**Jouanneau, J. M., and Latouche, C.** 1981. The Grionde Estuary. Contributions to *Sedimentology No. 10*, E. Schweizerbart'sche Verlagsbuchhandlung (Nägele u. Obermiller), Johannestrasse 3 A, D-7000 Stuttgart 1, West Germany.

An outline of the hydrology, sedimentology, geochemistry, and geological history of the Gironde Estuary. The authors present a model for the development and maintenance of the Gironde, one of the few estuaries in the temperate zone, particularly of Europe, in which little human interference has occurred during its history.

Kang, Y. Q. 1984. An analytic model of tidal waves in the Yellow Sea. *Journal of Marine Research* 42(3):473-485.

Cooscillating tides in the Yellow Sea south of Shantung Peninsula are investigated analytically by a superposition of Kelvin and Poincaré waves. The Yellow Sea is approximated by a rectangular bay of uniform depth with an opening at the head, and a variable portion of tidal energy is allowed to penetrate through the opening. The analytical results basically agree with the available tidal charts. For the semidiurnal tide, the Poincaré waves play an important role throughout the whole basin of the Yellow Sea, but for the diurnal tide their influence is restricted to the vicinity of the bay head. The asymmetry of the amphidromic system arises due primarily to a partial penetration of tidal energy through the opening at the bay head. A large tidal elevation in the Kyunggi Bay south of Ongjin Peninsula is due to the modifications of Kelvin and Poincaré waves at the Ongjin Peninsula. (11 refs)

Kawahara, M., Hirano, H., Tsubota, T., and Inagaki, K. 1982. Selective lumping finite element method for shallow water flow. *International Journal for Numerical Methods in Fluids* 2(1):89-112.

A finite element method for solving shallow-water flow problems is presented. The standard Galerkin method is employed for spatial discretization. The numerical integration scheme for the time variation is the explicit two-step scheme, which was originated by the authors and their co-workers. However, the original scheme has been improved to remove the erroneous artifical damping effect. Since the improved scheme employs a combination of lumped and unlumped coefficients, the scheme is referred to as a selective lumping scheme. Stability conditions and accuracy are investigated by considering several numerical examples. The method has been applied to the tidal flow in Osaka Bay and Yatsushiro Bay. (69 refs)

Kelly, L. R., and Andrews, J. C. 1985. Numerical models for planning coastal circulation studies. In

1985 Australasian conference on coastal and ocean engineering, 2-6 December 1985, Christchurch, New Zealand, 2:445-454. Barton, A.C.T., Australia: The Institution of Engineers, Australia.

A pair of fast and simple numerical circulation models are used to investigate tidal and wind-driven currents in a coastal environment. The models are easy to set up and inexpensive to run and can be used for circulation studies that form the bases of environmental impact studies in coastal regions where interest is focussed on the fate of natural and/or artificial contaminants, or on changes in water circulation caused by proposed engineering works. The approach is exemplified for Bowling Green Bay near 19 °S on the Queensland coast. Historical data on offshore currents are analyzed for spectral content to show the adequacy of modelling tidal and weather-band motion separately. Tidal band boundary conditions are determined from historical far field current ellipses and nearby historical height measurements. The same current meter data are used with historical wind data to determine weather-band boundary conditions by regressing lagged low-frequency longshore currents on winds. Details of the numerical schemes are given together with results in terms of the principal circulation features and the subsequent deployment of instruments. (7 refs)

Kendrick, M. P., Derbyshire, B. V., and Stevenson, T. A. 1985. Harbor siltation - Physical model and computational studies to establish present cause and predict post-development siltation rates. In *International conference on numerical and hydraulic modelling of ports and harbours,* 23-25 April 1985, Birmingham, England, ed. J. H. Pounsford, 139-148. Cranfield, Bedford, England: BHRA, The Fluid Engineering Centre.

Siltation in a tidal basin was thought to be due either to bankslip and land runoff following dredging, or to deposition from sediment suspended throughout the flow depth. The paper describes the studies made after calculations based on the available field data had shown that neither one alone nor both combined could be the primary cause. Offshore field measurements supported by laboratory experiments suggested the existence of a near-bed turbid layer a few centimeters thick which was formed under wave action over shallow mud banks flanking the port approach channel and transported into the harbor by modest residual currents. Low ebb current velocities ensured its residence and subsequent consolidation on the bed. On a physical hydraulic model the saline, near-bed water entering the basin was dyed black and the surface seeded with white floats. An overhead television camera provided a video recording of harbor tidal circulation and the volume of bed water entering per tide was calculated from the effective entrance width and velocity of the dyed layer at given tidal stages. This technique, with refinements, was used to predict harbor siltation following future port development. (4 refs)

Kennedy, V. S., ed. 1984. *The estuary as a filter*. Orlando, FL: Academic Press.

This text contains papers that were presented at the seventh biennial conference of the Estuarine Research Federation held in later October 1983. In five invited sessions, scientists and managers considered the physical, geological, chemical-geochemical, and biological processes involved in the "filtering" role of estuaries and reflected on management implications of these matters. Most of their presentations are included in this book to demonstrate what is known and what needs to be explored further. The timely presentations of this material should be beneficial to scientists and managers concerned with estuaries, their structure and function, and the impact of human use of these ecosystems. The abstract of each paper listed in the following contents can be found under the appropriate section of this bibliography.

Contents: The estuary as a filter: An introduction, by J. R. Schubel and Victor S. Kennedy; Turbulence and mixing in estuaries, by K. f. Bowden; Vertical variations in residual current response to meteorological forcing in the mid-Chesapeake Bay, by D. W. Pritchard and M. E. C. Vieira; Transport variability in a fjord, by G. A. Cannon, D. E. Bretschneider, and J. R. Holbrook; The estuary as a filter for fine-grained suspended sediment, by J. R. Schubel and H. H. Carter; The estuary as a sediment trap: Alternate approaches to estimating its filtering efficiency, by Robert B. Biggs and Barbara A. Howell, Recent sedimentation rates in Chesapeake Bay, by Charles B. Officer, Daniel R. Lynch, George H. Setlock, and George R. Helz; The role of flocculation in the filtering of particulate matter in estuaries, by Kate Kranck; The fates of uranium and thorium decay series nuclides in the estuarine environment, by J. Kirk Cochran; Response of Northern San Francisco Bay to riverine inputs of dissolved inorganic carbon, silicon, nitrogen, and phosphorus, by Lawrence E. Schemel, Dana D. Harmon, Stephen, W. Hager, and David H. Peterson; The estuarine interaction of nutrients, organics, and metals: A case study in the Delaware Estuary, by Jonathan H. Sharp, Jonathan R. Pennock, Thomas

M. Church, John M. Tramontano, and Luis A. Cifuentes; Estuarine total system metabolism and organic exchange calculated from nutrient ratios: An example from Narragansett Bay, by Scott W. Nixon and Michael E. Q. Pilson; Anthropogenic nitrogen loading and assimilation capacity of the Hudson River estuarine system, USA, by Thomas C. Malone; The estuary extended - A recipient-system study of estuarine outwelling in Georgia, by Charles S. Hopkinson, Jr., and Frederick A. Hoffman; Surface foam chemistry and productivity in the Duckabush River estuary, Puget Sound, Washington, by Robert C. Wissmar and Charles A. Simenstad; Micro-biological changes occurring at the freshwater-seawater interface of the Neuse River Estuary, North Carolina, by Robert R. Christian, Donald W. Stanley, and Deborah A. Daniel; Influences of submersed vascular plants on ecological processes in Upper Chesapeake Bay, by W. Michael Kemp, Walter R. Boynton, Robert R. Twilley, J. Court Stevenson, and Larry G. Ward; The seagrass filter: Purification of estuarine and coastal waters, by Frederick T. Short and Catherine A. Short; Biological and physical filtering in arid-region estuaries: Seasonality, extreme events, and effects of watershed modification, by Joy B. Zedler and Christopher P. Onuf; Assessing and managing effects of reduced freshwater inflow to two Texas estuaries, by Nicholas A. Funicelli; Deterioration of coastal environments in the Mississippi Deltaic Plan: Options for management, by Donald F. Boesch, John W. Day, Jr., and R. Eugene Turner; An environment characterization of Chesapeake Bay and a framework for action, by Virginia K. Tippie; Environmental impact of pollution controls on the Thames Estuary, United Kingdom, by Peter Casapieri.

†**Kessler, T. A.** 1986. Mixing-primary production coupling in Holberg Inlet, a tidally energetic fjord. Ph.D. diss., University of British Columbia, Vancouver, BC, Canada.

Wind and tidal mixing effects on primary production are investigated in the Holberg-Rupert basin, a fjord characterized by an inflow tidal jet and a seasonal growing cycle characteristic of well-mixed coastal water masses. An ≈ 7-year data set of environmental and primary production variables is evaluated statistically to infer the characteristic spatial and temporal scales of production in the basin, along with possible factors contributing to this distribution. The analysis indicates that persistent (i.e., orthogonal) horizontal features are generally lacking on the 1-month sampling time scale, except for structure shown to be evident in surface chlorophyll specific biomass distribution on the largest length scales of the basin (i.e., ca. 20 km). Consistent with the mass balances, a partial correlation analysis of the same data set indicates that aside rom irradiance, the dominant covariate of primary production is column stability, with the covariance of carbon uptake anticorrelated with stability. However, the covariance of biomass with stability is shown to be seasonally dependent (i.e., anticorrelated in the spring/fall and correlated in midsummer). Short time scale (i.e. high resolution) time-series of the vertical distribution of primary production variables are presented to demonstrate the evolution of vertical structure in these variables. The regular chlorophyll maximum feature in these time-series is suggested to be predominantly the result of a behavioral response to high irradiance and/or low ambient nutrients, though depth-dependent growth is shown to be important on occasion. A numerical model is constructed incorporating the structure and function indicated to be important. Numerical experiments are carried out evaluating model sensitivity to wind and column stability forcing. The results are interpreted to suggest that surface mixing control of primary production probably does not occur through vertical displacement effects on the near field light regime, but rather is related to phytoplankton nutrition; while nonmonotonic responses by the primary production output variables in the model to monotoni changes in wind forcing is interpreted as indicating that nonlinear coupling in the governing equations could be responsible for the observed covariance structure.

Kikukawa, H., and Ichikawa, H. 1984. An improved explicit finite element method for tidal flow. *International Journal for Numerical Methods in Engineering* 20*8):1461-1475.

A weighting function by which the mass matrix is made to be diagonal is deduced on the two-dimensional simplex element. Adopting the weighted residual method with the deduced weighting function for spatial domain and the two-step Lax-Wendroff method for time differentiation, the two-dimensional tidal flow in a model basin is calculated by means of the explicit finite element method. The water mass transport integrated over one tidal period at some cross sections of the basin is also estimated, in order to verify the water mass conservation. It is found that the water mass is nearly conserved in the present method, although the usual lumped mass matrix technique fails to conserve. The present explicit finite element method with the conservative form of

governing equations is also investigated and the water mass conservation is found to be a little more improved in this case than in the case of nonconservative forms. Application to a real bay indicates that the method with the conservative form of equations could be used for the estimation of tidal residual flow. (16 refs)

Kilset, K., and Heiberg, A. 1988. Evaluation of the "Fugacity" (FEQUM) and the "EXAMS" chemical fate and transport models: A case study on the pollution of the Norrsundet Bay (Sweden). *Water Science and Technology* 20(2):1-12.

Two different models have been used to investigate how chemicals present in wastewater from a kraft mill are transported and spread in an aquatic environment. The models, FEQUM (Fugacity EQUilibrium Model) and EXAMS, are presented, their characteristics explained, and a comparison of the models made. In FEQUM the concept of fugacity is considered as the driving force behind chemical transport. The EXAMS dispersion model uses water and sediment flow as the basis for calculating the dispersion of chemicals. FEQUM encompasses the whole environment; water, air, soil sediments, suspended matter in water and biota; whereas EXAMS includes the aquatic domain only. Both models have been applied to the Norrsundet area. Norrsundet is a heavily polluted bay on the east coast of Sweden. The pollution is due mainly to a kraft mill located in the area. The models were calibrated using data on chloroform in wastewater and seawater, and then tested on four other pollutants present in the wastewater. Both models given satisfactory results for the compounds investigated, tetrachlorocatechol constituting the only exception. Correlation coefficients between calculated and measured concentrations vary from 0.86 to 0.97. The poor results obtained for tetrachlorocatechol are probably due to the especially height affinity of this compound for suspended particles. (19 refs)

King, I. P., Granat, M. A., and Ariathurai, C. R. 1986. An inundation algorithm for finite element hydrodynamic and sediment transport modeling. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:1583-1593. University, MS: University of Mississippi.

A two-dimensional hydrodynamic and sediment transport finite element modeling system is presented. A subroutine allowing areas of interest to wet and dry during the simulation has substantially improved and broadened modeling capabilities. The models are described detailing the method of analysis used to simulate alternate flooding and drying within the computational area of interest. Two alternate procedures are described, and experience with each method is discussed. Application of the models to the simulation of the Cumberland Sound, Georgia, estuarine system is presented. This system consists of an inlet from the Atlantic Ocean, a maintained deep navigation channel leading into a harbor facility located adjacent to extensive marsh areas, and several smaller channels and creeks leading into other marsh and estuarine areas. The finite element network, bathymetry, and flow regime are described. Hydrodynamic simulations conducted with and without the wetting and drying routine are presented. In the latter case, the bed elevations were manipulated to preserve a constant geometry (i.e., marsh elevations were artificially lowered below mean low water). Result for stage (water elevations) and velocity are compared with physical model measurements. Results from the sediment transport model using the wetting and drying routine are compared with field shoaling observations. Although the present application is for an estuarine system, the modeling approach may also be used for riverine flood situations. (12 refs)

Koblinsky, C. J. 1981. The M_2 tide on the West Florida Shelf. (See complete entry in Section VIII.)

Koutitas, C. G. 1986. Coastal circulation and sediment transport. (See complete entry in Section II.)

†**Kowalik, Z.** 1981. A study of the M_2 tide in the ice-covered Arctic Ocean. *Modeling, Identification and Control* 2(4):201-223.

A model to study M_2 tide propagation in the Arctic Ocean based on the equation of motion of the water and the pack ice is considered. The mechanics of the ice floe interaction are described by the nonlinear viscous constitutive law. Various empirical parameters entering the constitutive law are checked against the tide-induced motion of the pack ice. The distribution of the amplitude, phase, current ellipse in the ice-free and the ice-covered Arctic ocean is computed and presented in figures. Special attention is given to clarifying the distribution and peculiarities of tide propagation in the Barents Sea. The tide-induced motion of the pack ice has been studied carefully; numerous experiments show that residual (voer tidal period) ice drift is observed due to the nonlinear ice floe interaction. It is found that both

residual ice drift and periodical ice motion may lead to ice redistribution, setting the areas of ice convergence and divergence.

Kuiper, J., de Wilde, P., and Wolff, W. 1984. Effects of an oil spill in outdoor model tidal flat ecosystems. *Marine Pollution Bulletin* 14(3):102-106.

For several reasons the fate and effects of oil pollution are not easily studied in natural ecosystems. Furthermore, the results of laboratory tests cannot easily be extrapolated to natural systems. A logical objective of ecotoxicological research is, therefore, to simulate natural systems in model ecosystem experiments. A 1-year feasibility study was carried out with Model Tidal Flat ecosystems (MOTIF's), designed to represent tidal flat systems typical of the Wadden Sea and other temperate estuarine areas. During the first 6 months, the four MOTIF's studies developed very similarly. After this period an oil spill was simulated by exposing two of the four MOTIF's to a floating oil mousse for 1 week. During this week part of the oil was buried in the sediment by bioturbation. This sediment-bound fraction caused a prolonged exposure of the MOTIF's to oil compounds. Short- and long-term effects resulted in large differences between oil-treated and control MOTIF's. These differences persisted to the end of the experiment, 7 months after the removal of most of the oil. (14 refs)

Kuo, A. Y., and Neilson, B. J. 1988. A modified tidal prism model for water quality in small coastal embayments. *Water Science and Technology* 20(6/7):133-42.

A water quality model was developed for easy application to small coastal embayments. The simulation of physical transport processes is based on Ketchum's tidal prism theory, modified and expanded such that it becomes applicable to cases where the embayment is branched and/or freshwater discharge is negligibly small. A model coastal embayment was divided into segments of lengths equal to local tidal excursions. Instead of starting the segmentation from landward end with freshwater discharge and tidal prism as two nonzero parameters, the modified model subdivides the water body starting from the seaward end with the difference between tidal prism and freshwater discharge as a single parameter. The mass balance within each segment was formulated by considering the exchange of water with its neighboring segments due to the flushing of freshwater discharge, as well as the tidal prism on ebb cycle, and to the mixing of the tidal prism on flood tide. This results in an algebraic equation which may be solved for concentration in each segment by successive substitution. For a nonconservative substance, the biochemical reaction terms may be easily added to the algebraic equation without complicating the solution scheme. The model has been applied to a number of tidal creeks and coastal embayments in Virginia, USA. The application to the Lynnhaven Bay is presented. (4 refs)

Lee, J. K., Schaffranek, R. W., and Baltzer, R. A. 1989. Convergence experiments with a hydrodynamic model of Port Royal Sound, South Carolina. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 434-441. New York: ASCE.

A two-dimensional, depth-averaged, finite-difference, flow-transport model, SIM2D, is being used to simulate tidal circulation and transport in the Port Royal Sound, South Carolina, estuarine system. Models of a subregion of the Port Royal Sound system have been derived from an earlier developed model of the entire system having a grid size of 600 ft. The submodels were implemented with grid sizes of 600, 300, and 150 ft in order to determine the effects of changes in grid size on computed flows in the subregion, which is characterized by narrow channels and extensive tidal flats that flood and dewater with each rise and fall of the tide. Tidal amplitudes changed less than 5 percent as the grid size was decreased. Peak cross-sectional discharges obtained by using the 600-ft submodel increased on the average about 25 percent when the grid size was decreased to 300 ft, and peak discharges obtained by using the 300-ft submodel increased on the average an additional 6 percent when the grid size was further decreased to 150 ft. Simulations were performed with the 300-ft submodel for time-steps of 60, 30, and 15 sec. Water levels did not change as the time-step changed. Peak cross-sectional discharges did not change when the time-step was decreased from 30 sec to 15 sec but changed by up to 5 percent when the time-step was increased from 30 sec to 60 sec. (6 refs)

Leendertse, J. J. 1988. Influence of the advection term approximation on computed tidal propagation and circulation. (See complete entry in Section VIII.)

†**Leendertse, J. J.** 1981. SIMSYS2D: A two-dimensional flow and water quality simulation system. Santa Monica, CA: The Rand Corporation.

The SIMSYS2D system is designed for two-dimensional simulation of hydrodynamics and water quality in well-mixed estuaries, coastal seas, harbors, and inland waters. This publication describes the nine programs involved, and discusses the characteristics of this finite difference method model, with staggered grid. It outlines choices in terms of the hydrodynamic equations, boundary conditions (including use of singular points to simulate barriers and outfalls), and treatment of the transport equations. Applications of the model to the Eatern Scheldt, The Netherlands, are illustrated, and future developments outlined.

†**Leendertse, J. J.** 1984. Verification of a model of the Eastern Scheldt. Report R-3108-NETH. Santa Monica, CA: Rand Corporation.

This report describes a verification simulation of a model of the Eastern Scheldt. Boundary conditions for a simulation of flows and water levels were obtained from gauging stations in the offshore area of the estuary by use of weighting functions obtained from simulations with other models in the offshore area. Two investigate the effect of the representation of a narrow channel, called the Eendracht, with the two-dimensional representation of the model, two experiments were made with a part of the model extending eastward from the Zealand bridge. These experiments indicated that the accuracy of the model in the vicinity of the channel ends can be improved by coupling the two-dimensional model with a one-dimensional representation of this channel. These experiments also indicated that tide gauge data at existing stations can be used directly as boundary conditions for this part of the model, but only in the vicinity of the model boundary are the flow patterns incorrect during some phase of the tide. Some modification of the input will be required to correct this deficiency. In the verification simulation, pressures resulting from salinity differences were included in the computation. An average salinity distribution was an input at the start of the simulation. Simulation results indicated a very good agreement between observed and computed transport rates through the Hammen, Schaar, and Roompot. A good agreement between observed and computed water levels was also obtained. The simulation in which the pressure resulting from salinity were included had a better agreement with observed data than the simulation without the salinity. An analysis of the different components of the observed and computed waters indicated that, in general, the quarterdiurnal tidal component was the most difficult to reproduce in the model. (16 refs)

Leendertse, J. J., Langerak, A., and de Ras, M. A. M. 1981. Two-dimensional tidal models for the Delta Works. In *Transport models for inland and coastal waters,* Proceedings of a Symposium on Predictive Ability, 18-20 August 1980, Berkeley, CA, ed. Hugo B. Fischer, 408-450. New York: Academic Press.

A 5-mile storm surge barrier is being built across three inlets in the Oosterschelde. This and the construction of secondary dams, sluices, and locks associated with these dams will reduce the tidal area of the Eastern Scheldt by about 20 percent and make the waterway between Antwerp and the Rhine free of any tidal influence. Model studies are directed toward the investigation of the change in offshore tidal currents and its effect on sediment transport in this offshore area. Data are also supplied to wave diffraction/refraction models, and with the two-dimensional model the barrier closing strategies are being verified. The model is also being used to predict salinity and water quality in the Oosterschelde as a result of the construction works. (3 refs)

Li, C. W., Lee, J. H.-W., and Cheung, Y. K. 1986. Mathematical model study of tidal circulation in Tolo Harbour, Hong Kong: Development and verification of a semi-implicit finite element scheme. *Proceedings of the Institution of Civil Engineers* 81(2):569-592.

The tidal circulation in Tolo Harbour, Hong Kong, is computed by a newly developed semi-implicit finite element model. The accuracy and efficiency of the unconditionally stable time-stepping scheme are confirmed by a detailed Fourier analysis and extensive tests against analytical solutions of long wave propagation in basins of varying lateral topography and bottom bathymetry. With M_2 tidal forcing at the seaward (open) boundary, the model is capable of reproducing the near standing wave and characteristic circulation in the bay. Computed velocities and elevations are also validated against good quality field data in a verification study. It is found that accurate input tides at the seaward boundary of the model are needed to simulate the propagation of the complex shallow-water tides in the study area. The correctly simulated tidal phase lag between the open boundary and inshore is found to be at variance with data in published tide tables. (20 refs)

Lill, C. C., and Braddock, R. D. 1980. The evaluation of tide well constants. In *7th Australasian conference on hydraulics and fluid mechanics,* 18-22 August 1980, Brisbane, Australia, 377-380.

Barton, Australia: Institution of Engineers.

The role of viscous dissipation of energy in the operation of the common tide well is considered in detail, and method of determining the viscous constants is described. Only measurements of the water level are required; this avoids the difficulties in obtaining accurate measurements of the fluid velocity. The results obtained demonstrate marked differences between the inflow and outflow regimes of an operating tide well. The friction coefficient is sensitive to variations in the orifice geometry. (8 refs)

Lin, H.-C. J., and Martin, W. D. 1989. Newport News channel deepening study, Virginia; Numerical model investigation. Technical Report HL-89-12. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

This report presents results from the numerical model investigation whose primary objective was to evaluate general changes in circulation, currents, and sedimentation associated with the overdeepening of the Newport News Channel. An additional objective of the study was to assess the effects of the overdeepening on the reported estuarine circulation cell (flow convergence) off Hampton Flats and Newport News Point. Three alternative plans of overdeepening, 57 64, and 70 ft, were evaluated. This numerical model investigation used the TABS-2 finite element numerical RMA-2V for hydrodynamic analysis and STUDH for sediment transport computation with a modified version of an existing numerical mesh (expansion plan B) of the Lower James River. Results from the numerical hydrodynamic modeling indicated no velocity increases in the Willoughby Bay area. The maximum velocity change in the channel was 0.2 fps. No circulation changes were identified in the base-to-plan comparison of velocity vector plots. Additionally, no change in tidal phasing or water-surface elevation was detected. The formation and location of the two-dimensional circulation cell off Newport News Point were unaffected by any of the plans. Results from the sedimentation modelling showed that a maximum decrease in shoaling in the Hampton Flats area was about 7 percent, a maximum increase in shoaling in the Newport News Channel was less than 1 percent, and a maximum increase in shoaling in the Willoughby Bay area was about 6 percent. The various deepening plans resulted in a redistribution of sediments with a net loss over the Hampton Flats area and a net increase in the Willoughby Bay area. The channel will experience a slow rate of shoaling due to the overdeepening. However, all changes in sedimentation were small in absolute volumes. The reported frontal effect off Newport News Point is a three-dimensional density current-driven phenomenon and cannot be quantified within the two-dimensional analysis. However, no evidence was generated by this study that would indicate that the channel over deepening will affect the front formation or propagation. (7 refs)

Lincoln, J. M., and Fitzgerald, D. M. 1988. Tidal distortions and flood dominance at five small tidal inlets in southern Maine. (See complete entry in Section I.)

Liu, J. T.-C. 1987. Sediment patterns and shoreface bathymetry as a key to understanding shoreface dynamics: A case study of the south shore of Long Island, New York. Ph.D. diss., State University of New York at Stony Brook.

A conceptual model regarding the maintenance of an equilibrium shoreface is tested on the shoreface of Long Island, New York. In addition to the results, the fruitful and innovative method used by this study is also an important contribution to the field of marine geology by this study. Morphodynamically, the shoreface of the study area is composed of two systems: a barrier island section and a headland section. Major shoreface morphological components of both sections are initially formed by seaward storm sediment transport, and subsequently modified and maintained by fair-weather hydrodynamic processes. The shape of the equilibrium shoreface of the study area is controlled by the slope of the pre-existing outwash plain, shoreface hydrodynamic regime, and probably the rate of sea level rise. The seaward extent of the shoreface of the study area is at depths between 14 and 16 m, defined by the characteristic equilibrium response of individual grain sizes to the average shoreface hydrodynamic regime. The positions of dynamic equilibrium of four morphodynamically distinctive grain-size groups on the upper shoreface indicate a seaward fining sequence from the swash zone to the seaward extend extent of the upper shoreface. The bluff composed of morainal material in the headland section and back barrier lagoons in the barrier island section are two external sediment sources for the study area. Within the shoreface system, a remnant terminal moraine lobe complex, sediments associated with old tidal inlet channels, and the 'relict' outwash plain deposits are permanent (irreversible) sediment sources. The present shoreface sediments are derived primarily from the relict outwash plain sediments as a result of in situ reworking by the present shoreface hydrodynamic regime. This reworking is achieved by the

retention of very fine and fine sands in the upper shoreface and the depletion of medium sands from the middle and lower shoreface. Other temporary internal sediment sources are storm deposits, modern shoreface depositional features such as nearshore bars, sand ridges, and active ebb tidal deltas. As sea level rises, the shoreface will probably continue to migrate landward, maintaining the present geometry. The recessional shoreface also will leave behind a sheet of relict transgressive sand, composed of mainly medium sands as the result of the winnowing of fine-grained sediments by the hydrodynamic processes of the traversing shoreface.

Loder, J. W., and Wright, D. G. 1985. Tidal rectification and frontal circulation on the sides of Georges Bank. (See complete entry in Section I.)

Lowery, T. A. ed. 1987. *Symposium on the natural resources of the Mobile Bay Estuary.* (See complete entry in Section V.)

Lung, W.-S. 1986. Assessing phosphorus control in the James River Basin. *Journal of Environmental Engineering,* ASCE, 112(1):44-60.

A tidally averaged water quality model was used to study the factors limiting the phytoplanton growth in the James River Estuary in Virginia. The water quality constituents simulated by the model are carbonaceous biochemical oxygen demand (CBOD), dissolved oxygen, organic nitrogen, ammonia nitrogen, nitrite plus nitrate nitrogen, organic phosphorus, inorganic phosphorus, and chlorophyll a. The kinetics of major physical, chemical, and biological processes which link these water quality constituents are modeled in each of the 50 model segments in the longitudinal direction of the upper James River Estuary. Model calibration and sensitivity analyses indicate that the phytoplankton growth plays a significant role in contributing to ultimate CBOD through respiration of live phytoplankton as well as recycling of carbon from dead algal biomass. In addition, algal growth is important in balancing the dissolved oxygen budget via photosynthesis and respiration. More importantly, turbidity controls the phytoplankton growth. Nutrients (nitrogen and phosphorus) are found not to be a key limiting factor in the upper James River Estuary under the present conditions. However, the model projection analysis indicates that significant phosphorus load reduction from municipal wastewater treatment plants would reduce phosphorus to levels that limit the phytoplankton growth and thereby control phytoplankton biomass to reasonable and manageable levels. (6 refs)

Lung, W.-S. 1988. The role of estuarine modeling in nutrient control. *Water Science and Technology* 20(67):243-252.

Two case studies are presented to demonstrate how estuarine water quality models can be used in planning eutrophication control. In the first study, the steady-state model is used to assess the impact of point source phosphorus reduction on the phytoplankton biomass in the upper James Estuary in Virginia during the summer months. The modeling results indicate that phosphorus is in ample supply to support the phytoplankton growth in the system. However, substantial reduction of loads by phosphorus removal at the wastewater treatment plants would lead to a phosphorus-limiting condition, thereby lowering the phytoplankton biomass levels. In the second study, a time-variable model is developed to investigate the potential of blue-green algal *(Microcystis)* blooms in the Neuse Estuary in North Carolina. More specifically, the model is designed to address two management questions. First, recognizing that high nonpoint nitrogen loads in the spring months would lead to a proliferation of non-nitrogen fixing blue-green genera, should parallel control of nitrogen be considered? Second, in light of the potential for algae species dominance to shift, is control of nitrogen-fixing blue-green algal blooms possible? Based on the modeling calibration results using data from 1983, 1984, and 1985 under different hydrologic conditions, freshwater flow to the estuary is found to be a key factor in controlling blue-green algal blooms in the Neuse Estuary.

†McAnally, W. 1981. Modeling: How and when to use. *Ocean Science Engineering* 6(2):149-162.

Modeling is widely employed to solve estuarine sedimentation problems. In order to decide if the modeling is an appropriate approach for a particular problem, the researcher must understand the physical processes contributing to the sedimentation problem, have a general idea of the types of remedies that might be used to solve the problem, and know the strengths and weaknesses of methods available to study the problem. (12 refs)

McAnally, W. H., Jr., and Stewart, J. P. 1982. Hybrid modeling of estuarine sedimentation. In *Proceedings of the conference applying research to hydraulic practice,* 17-20 August 1982, Jackson, MS,

ed. Peter E. Smith, 408-417. New York: ASCE.

A hybrid modeling method using physical and numerical models in an integrated solution method has been developed for use in solving estuarine sedimentation problems. The method was applied to the Columbia River Estuary with a large physical model, finite element numerical models RMA-2V and STUDH, a finite difference wave propagation model, and several analytical techniques. (7 refs)

McAnally, W. H., Jr., Letter, J. V., Jr., and Thomas, W. A. 1986. Two and three-dimensional modeling systems for sedimentation. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:400-411. University, MS: University of Mississippi.

Two- and three-dimensional numerical modelling systems have been developed to address questions of open channel flow and sedimentation for the US Army Corps of Engineers. These systems provide for all major activities needed in a numerical modelling study. They have been applied in a number of two-dimensional hybrid and numerical modelling studies of sedimentation, including the Columbia River Estuary, the Arkansas River, and Norfolk Harbor. The three-dimensional system has been applied to New York Harbor and is now being used in a study of the Mississippi River. These applications illustrate the versatility of the system and of the hybrid modelling method. (13 refs)

McTamany, J. E. 1982. Evaluation of physical and numerical hydraulic models, Masonboro Inlet, North Carolina. GITI Report 22. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

A fixed-bed distorted-scale physical model, a two-dimensional vertically integrated numerical model, and a spatially integrated numerical model were calibrated to determine prototype conditions at Masonboro Inlet, North Carolina, in September 1969. Comparison of model results with prototype data showed that the physical model and the two-dimensional numerical model reproduced prototype conditions equally well. A second complete set of prototype data, including revised bathymetry in each model, was subsequently obtained at Masonboro Inlet in July 1974. After the bathymetry was updated, the models were run using the observed ocean tide as a forcing condition. The model predictions were then compared with prototype data without further recalibration. Both the physical and the two-dimensional numerical models reproduced observed tidal records and vertically averaged velocities equally well. No appreciable improvement in tidal height or velocity predictions was obtained by modeling prototype wind waves in the physical model. The waves caused a slight increase in bay water levels that also occurred in the prototype. Neither numerical model had the capability to model wind waves. The spatially integrated model only predicts the average bay water level and the inlet mean velocity time-histories. The predictions from the other models and the prototype data were averaged for comparison with the spatially integrated model. The spatially integrated model did not predict the average bay levels as well as the other models; however, it did predict the mean inlet velocities significantly better than the other two models. The accuracy of the spatially integrated model in predicting mean inlet velocities appears to be less sensitive to calibration than the more detailed physical and numerical models tested in this study. (13 refs)

Malone, F., Kuo, J. T., and Chen, N. M. 1982. Finite element modeling of tides and currents of the New York Bight. In *Ocean '82 conference record: Industry, government, education...Partners in progress,* 20-22 September 1982, Washington, DC, 7810783. Piscataway, NJ: The Institute of Electrical and Electronics Engineers, Inc.

Semiimplicit time integration schemes have been combined with finite element space discretization in developing a numerical scheme for the solution of the classical shallow-water equations. The scheme has been applied to determine the M_2 tides and currents in the New York Bight. Comparison of the M_2 tides and currents in the New York Bight with those of Project MESA gives good agreement. (6 refs)

Marche, C., Quach, T. T., and Prud'homme, J. 1989. The tides effects on the dam break flood wave. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 1194-1199. New Yorks: ASCE.

The numerical computation of the dam break flood gives a good estimation and defines the maximum extension of the flooded area. The accuracy of the level predictions downstream of the dam is dependant upon the breach evaluation, the correct estimation of the roughness coefficients, and when the flood wave reaches the downstream part of the valley on the estuary zone, the tidal effect. Therefore, the

hydraulic boundary conditions to be imposed downstream of the discretized valley must be chosen very carefully to ensure the validity of the results at all stages of the dam break flood wave. This presentation tries to propose a computational approach to minimize error induced by tide-induced boundary conditions. (2 refs)

Martin, Q. W. 1987. Estimating freshwater inflow needs for Texas estuaries by mathematical programming. *Water Resources Research* 23(2):230-238.

As mandated by the Texas State Legislature, the Texas Department of Water Resources conducted studies of the effect of freshwater inflows upon the bays and estuaries of Texas. Developed as part of these studies, a mathematical programming model is described for computing estimates of the monthly and seasonal freshwater inflows necessary to meet specified environmental conditions in each of the major estuaries of the Texas Gulf Coast. The optimization model relates freshwater inflow to the key estuarine indicators of salinity, marsh inundation, and commercial fisheries harvests. Three management proposals are formulated for each estuary, corresponding to ecosystem subsistence, maintenance of fisheries harvests, and fisheries harvest enhancement. Linear and nonlinear mathematical programming techniques are used to determine the optimal inflows for each of these three management alternatives in all but one of the seven major estuaries, where only one of the management proposals could be solved. (26 refs)

Mayer, D. A., Leaman, K. D., and Lee, T. N. 1984. Tidal motions in the Florida current. *Journal of Physical Oceanography* 14(10):1551-1559.

A linear relationship exists between sea level and the north component of the depth-averaged tidal velocity in the Straits of Florida. This relationship is used as a one-dimensional model to predict barotropic tidal currents across the straits near 27° N. Predictions are independent of the choice of a sea level reference site between Key West and Patrick Air Force Base. The model, when compared with three sets of depth-averaged velocity obtained from current profiles, can account for at least 70 percent of the variance in the diurnal and semidiurnal tidal bands. The predicted diurnal tidal current is dominant and can account for more than 80 percent of the predicted tidal energy. Twice corresponds to a tidal transport of 5.1×10^6 $m^3\ s^{-1} \pm 1.5 \times 10^6\ m^3\ s^{-1}$ (5.1 Sv). (16 refs)

Mays, J. 1987. Thorough and versatile tide prediction by computer. (See complete entry in Section VII.)

Mehta, A. J., and Joshi, P. B. 1988. Tidal inlet hydraulics. (See complete entry in Section I.)

Mehta, A., and Maa, P.-Y. 1986. Waves over mud: Modeling erosion. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:588-601. University, MS: University of Mississippi.

Wave-induced erosion of mud plays a critical role in governing sediment transport along muddy coasts and in estuarial reaches close to the sea. Since the bed typically tends to be soft, it oscillates in response to water wave motion during erosion. In addition, energy dissipation in the bed often results in a significant degree of wave height attenuation. In order to estimate the shear stress at the mud-water interface as well as to account for wave attenuation, a linearized, multilayered hydrodynamic model was developed, with the mud layer considered to be viscoelastic. The viscoelastic response of mud under small shear strain was confirmed by rheological measurements. Flume erosion tests involving progressive, nonbreaking waves were used to verify model prediction for flow kinematics and dynamic pressure response. These tests utilized beds composed of kaolinite and an estuarial mud. During erosion, a stratified suspension developed, with a near-bed layer of fluid mud. The rate of bed erosion, which was found to correlate with the bed shear stress, was in general different from the rate of upward entrainment of fluid mud. Fluid mud generation under waves is a key source of sediment in shoaled navigation channels. (17 refs)

Mehta, A. J., Partheniades, E., Dixit, J. G., and McAnally, W. H. 1982. Properties of deposited kaolinite in a long flume. In *Proceedings of the conference applying research to hydraulic practice,* 17-20 August 1982, Jackson, MS, ed. Peter E. Smith, 594-603. New York: ASCE.

Recent results from three laboratory tests on the deposition of kaolinite in water in a 100-m-long flume are reported. In each test, suspended sediment was allowed to deposited in the flume at selected values of discharge and depth of flow. The undeposited portion of the sediment passed out of the flume at the downstream end. Sediment accumulated in each 12.2-m segment of the 100-m-long deposited

bed was next resuspended in a 1.5-m-diameter and 0.21-m-wide annular rotating flume, and was allowed to deposit under a constant applied bed shear stress. The rates of deposition are found to follow a law similar to that derived from basic laboratory investigations of the depositional behavior of cohesive sediments reported previously. Parameters characterizing this law are found to exhibit significant variation along the length of the 100-m-long flume, implying a corresponding variation in the rates of deposition of the suspended aggregates. Differences in aggregate properties resulting from corresponding differences in the particulate composition of the aggregates appear to be a causative factor. The results elucidate a mechanism for sediment sorting which commonly occurs in muddy estuaries. (4 refs)

Meyer, Z., and Buchholz, W. 1988. Hydrology and hydrodynamics of the Odra Estuary with special reference to the influence of wind. (See complete entry in Section I.)

Miles, G. V., and Cooper, A. J. 1985. Application of a DAP computer to tidal problems. In *International conference on numerical and hydraulic modelling of ports and harbours,* 23-25 April 1985, Birmingham, England, ed. J. H. Pounsford, 75-81. Cranfield, Bedford, England: BHRA, The Fluid Engineering Centre.

Two applications in predicting tidal flows are presented and discussed. One concerns a study of the influence of dredging in an estuary and the other is of a buoyant plume for a proposed power station.

†**Mills, D. J. L.** 1988. The impact of hydrocarbon pollution on meiobenthic production within an estuarine mud-flat. (See complete entry in Section IV.)

Milne, R. A., Nicholas, P. C., Pattinson, C., and Halcrow, W. 1986. The definition of effluent discharge consent conditions in complex estuarine environments. (See complete entry in Section IV.)

†**Mirsajadi, H. D.** 1988. Development of a water quality-based mixing zone in estuaries. (See complete entry in Section IV.)

†**Mofjeld, H. O.** 1982. Recent observations of tides and tidal currents from the Northeastern Bering Sea Shelf. Seattle, WA: National Oceanic and Atmospheric Administration, Pacific Marine Environmental Laboratory.

Tide and tidal current observations from the Northeastern Bering Sea Shelf and a comparison of these observations with theory and numerical models are reported in this memorandum. Pressure observations (November 1981-August 1982) at seven stations show that the diurnal tides dominate the outer shelf. The diurnal amplitudes (maximum of 38 cm K1 and 26 cm for 01 at the shelfbreak) decrease exponentially inshore from the shelfbreak at a rate consistent with subinertial Sverdrup waves. The phase lags of the diurnal tides vary little (ranging from 322 degrees G to 359 degrees G for the K1 tide) over the shelf. The semidiurnal amplitudes (maximum of 23 cm for M2 at the shelfbreak) change considerably between stations; on the outer shelf there is some influence of a semidiurnal amphidromic system off Cape Navarin.

Nakamura, S. 1987. A note on numerical evaluation of tsunami threats by simple hydrodynamic and stochastic models referring to historical descriptions. (See complete entry in Section I.)

Nakamura, S. 1987. A numerical prediction of semidiurnal current patterns in Tanabe Bay. (See complete entry in Section I.)

Nassehi, V., and Williams, D. J. A. 1986. Mathematical model of Upper Milford Haven—A branching estuary. *Estuarine, Coastal and Shelf Science* 23(3):403-418.

A mathematical model for hydrodynamics and salt intrusion in a one-dimensional branching estuary has been developed. The model satisfactorily predicts water levels and discharges throughout Upper Milford Haven Estuary for spring and neap tides. There is also a measure of agreement between computed and observed salinities. (28 refs)

Nece, R. E. 1985. Physical modeling of tidal exchange in small-boat harbors. In *International conference on numerical and hydraulic modelling of ports and harbours,* 23-25 April 1985, Birmingham, England, ed. J. H. Pounsford, 33-41. Cranfield, Bedford, England: BHRA, The Fluid Engineering Centre.

This paper describes the use of physical hydraulic models to determine tidal flushing in saltwater marinas and to provide an economical basis on which decisions that might be governed by tidal flushing questions can be made on whether or not a project can be allowed to proceed. Model test procedures

are presented briefly, and some problems and limitations discussed. Results of a few studies are discussed, and the use of model test results in prototype design are illustrated. (12 refs)

Nece, R. E., and Smith, H. N. 1982. Photodensimetric methods in tidal flushing studies. In *Proceedings of the conference applying research to hydraulic practice,* 17-20 August 1982, Jackson, MS, ed. Peter E. Smith, 546-555. New York: ASCE.

This paper addresses one type of project, namely, small harbors, where simple, inexpensive physical hydraulic models still provide the most efficient mechanism for producing required information. Photodensimetric methods for quantifying tidal exchange in models of small harbors are described. Tidal exchange (flushing) has been considered a significant factor in the quality of water within small boat harbors relative to quality of ambient waters. (9 refs)

Neliessen, H. A. M. 1986. Foundation of the Eastern Scheldt storm surge barrier. (See complete entry in Section V.)

Nihoul, J. C. J., and Jamart, B. M., ed. 1987. *Three-dimensional models of marine and estuarine dynamics*. New York: Elsevier.

This book is a collection of 34 papers presented by more than 50 authors and co-authors at the International Colloquium on Ocean Hydrodynamics, Liège, 1986. Offering a valuable review of methods and new aspects of coastal and estuarine hydrodynamics, the papers are concerned with physical mechanisms which govern the fate of pollutants and create conditions of marine fertility. Topics include: growth and propagation of rental structures and eddies in limited areas, river plume fronts, thermal impact of coastal nuclear projects, circulation and vertical structure of storm-generated currents in shelf areas, response to wind fluctuations or to a high tidal regime, role of bottom friction and topography, impact of resuspended sediments, importance of stratification, boundary-layer effects on flows of different scales, and forecast problems for the oceanic mesoscale. The application of the models proposed and discussed by the authors is demonstrated by examples: Greenland-Norwegian Sea, Southwest Nova Scotia, Feroe and Shetland shelf, Northwest European continental shelf. Bristol Channel and Severn Estuary, Bay of Seine, Elbe Estuary, Western Baltic, Venice Lagoon, Strait of Messina, Gulf Stream, Florida Current, Charlotte Harbor/Florida, Gulf of Mexico, Canary basin, Brazil-Falkland currents confluence region, South Africa, California shelf, Southwest Pacific, South China Sea, and Bohai Sea/China.

Nguyen, K. D., and Martin, J.-M. 1988. A two-dimensional fourth-order simulation for scalar transport in estuaries and coastal seas. *Estuarine, Coastal and Shelf Science* 27(3):263-281.

The paper presents a fourth-order scheme for solving the strong advection problem in estuaries and coastal seas. The scheme is based on the characteristic method in conjunction with a bi-cubic interpolation for solving the advection term, and the implicit differencings following fractional steps for the diffusion term. The amplitude and phase error analysis and the one- and bi-dimensional tests carried out have shown that the proposed scheme is more accurate than other ones as such the upwind, leap-frog & Dufort-Frankel, Leenderste's alternating direction implicit (ADI) schemes. It is almost equivalent to the four-point fourth-order one, allowing a considerable decrease on the computing time and the storage requirement over the last. An application of the scheme to predicting the pollution by nitrates in the Moulinets cove (France) is given to illustrate this scheme. (26 refs)

Nunes, R. A., and Simpson, J. H. 1985. Axial convergence in a well-mixed estuary. (See complete entry in Section I.)

Odd, N. V. M. 1981. The predictive ability of one-dimensional estuary models. In *Transport models for inland and coastal waters,* Proceedings of a Symposium on Predictive Ability, 18-20 August 1980, Berkeley, CA, ed. Hugo B. Fischer, 39-62. New York: Academic Press.

This paper points out some of the pitfalls in applying the technique and various ways of analyzing and presenting the results. It also indicates the weaknesses and limitations of one-dimensional estuary models. (17 refs)

Odd, N. V. M., Wolfe-Barry, J. N., and Berrahim, A. 1985. Hydraulic modelling of a tidal lagoon at Benghazi. In *International conference on numerical and hydraulic modelling of ports and harbours,* 23-25 April 1985, Birmingham, England, ed. J. H. Pounsford, 43-49. Cranfield, Bedford, England: BHRA, The Fluid Engineering Centre.

Mathematical and physical model studies for the

Benghazi North Lakes Project are described. The coastal strip in the area of Benghazi is characterized by large, shallow coastal lagoons of sabkhas situated behind the coastal dunes. The program of model testing was designed to investigate effects; the increases in temperature and salinity likely during the summer months; and the extent of pollution likely to arise during the winter from the stormwater runoff. A physical tidal flow model, a complementary two-dimensional numerical tidal circulation model, and a new type of three-dimensional numerical model are used. (5 refs)

Oey, L.-Y., Mellor, G. L., and Hires, R. I. 1985. A three-dimensional simulation of the Hudson-Raritan Estuary; Part I: Description of the model and model simulations. *Journal of Physical Oceanography* 15(12):1676-1692.

A time-dependent, three-dimensional, finite difference simulation of the Hudson-Raritan Estuary is presented. The calculation covers July-September 1980. The model estuary is forced by time-dependent observed winds, tidal elevation at open boundaries, and river and sewage discharges. Turbulence mixing coefficients in the estuary are calculated according to a second-moment, turbulence-closure submodel. Horizontal diffusivities are zero in the simulation, and small-scale eddies produced by the interaction of unsteady, three-dimensional velocity and salinity fields with coastline and bottom bathymetry were resolved by the model. These eddies are important physical elements in shear dispersion processes in an estuary. Model results show unstably stratified water columns produced by advection of waters of different densities. These instabilities produce intense mixing with vertical eddy diffusivities reaching 2-3 times their neutral values. They occur most frequently at slack currents, during initial stages of flooding currents, and also during up-estuary wind events. These three-dimensional, time-dependent solutions extend previous analytical model results and are consistent with observations in partially mixed and well-mixed estuaries. Model results show large subtidal response of velocity and salinity fields to wind forcing. Wind forcing modifies the density-induced flows in deep channels in the estuary and also the horizontal circulation in Raritan Bay where the average water depth is less than 5 m and tidal currents are weak. (32 refs)

Oey, L.-Y., Mellor, G. L., and Hires, R. I. 1985. A three-dimensional simulation of the Hudson-Raritan Estuary; Part II: Comparison with observation. *Journal of Physical Oceanography* 15(12):1693-1709.

Results from a time-dependent, three-dimensional numerical simulation of the Hudson-Raritan Estuary are compared with observations. The comparison includes (a) instantaneous salinity contours across a transect in the estuary; (b) amplitudes and phases of tidal constituents at four tide gauge and five current meter stations; (c) mean currents at nine meter locations, and mean salinity in the Hudson River; (d) kinetic energy spectra; and (e) response to wind forcing of subtidal current at an observational station near the mouth of the estuary. Observations confirm the model's prediction of existence of density advection instabilities induced by differential advection of the three-dimensional density field. These instabilities produce intense vertical mixing and should significantly modify dispersion processes in the estuary. Effects of neap-spring tides on vertical stratifications are also simulated by the model. Simulated M_2 phases at three tide gauge stations show improvement over the M_2 phases obtained from a two-dimensional, vertically integrated tidal model. The improvement is presumably due to bottom boundary layer resolution and, therefore, improved representation of bottom friction in the three-dimensional model. Simulated (instantaneous and mean) currents compare reasonably well with observations, except at narrow channel regions where the model's resolution is inadequate. Simulated "density-induced" mean currents are weaker than those observed, a discrepancy attributed to neglect of temperature variations in the model. Horizontal diffusion coefficients are null in this model. The burden of horizontal dispersion is generally handled well by the model's adequate resolution of molal-scale advective processes, as suggested by the model's correct simulation of the k^3 transfer spectrum law at high wave number k. In narrow rivers that are modeled two dimensionally (x,z), the estimate of the horizontal dispersion due to vertical variabilities in velocity and salinity appears to be correct; however, mixing by lateral variability is absent so that the saline intrusion is somewhat under-predicted. At the mouth of the estuary, simulated subtidal current responses to wind forcing generally agree with observed responses. The response is partly barotropic, which is a result of balance between bottom friction, sea level setup from the adjacent continental shelf, and wind stress, modified by local vertical velocity shears and baroclinic responses. (17 refs)

Oey, L.-Y., Mellor, G. L., and Hires, R. I. 1985. A three-dimensional simulation of the Hudson-Raritan Estuary; Part III: Salt flux analyses. (See complete entry in Section III.)

Oey, L.-Y., Mellor, G. L., and Hires, R. I. 1985. Tidal modeling of the Hudson-Raritan Estuary. *Estuarine, Coastal and Shelf Science* 20(5):511-527.

Tidal flow characteristics in the Hudson-Raritan Estuary are studied with a two-dimensional, depth-averaged finite difference model. Rivers are modeled as one-dimensional channels with variable width and depth and are calculated as part of the two-dimensional calculations at no extra computational cost. A more extensive comparison of numerical tidal calculations with observational data than has previously appeared in the literature is presented. Computed velocity and tidal elevation fields compare well with observations. Comparison with observations at the Sandy Hook-Rockaway Point transect indicates that the barotropic tidal residual current contributes significantly to the overall steady circulation in the harbor. The residual current is mainly induced by the coastal geometry and bottom topography through the nonlinear inertia effects. (12 refs)

O'Keeffe, P., and Harding, P. 1985. The combined use of mathematical and physical models to represent the tidal behaviors of Gladstone Harbour. In *1985 Australasian conference on coastal and ocean engineering,* 2-6 December 1985, Christchurch, New Zealand, 2:495-507. Barton, A.C.T., Australia: The Institution of Engineers, Australia.

The high velocities in Gladstone Harbor generated by the large tidal range in Port Curtis have caused problems with the berthing and mooring of ships at several of the wharves within the harbor. The introduction of larger ships and future reclamation proposals within the harbor could exacerbate the existing problems and perhaps create new ones. A physical model of part of Gladstone Harbor was constructed to examine existing tidal flow patterns and the off-berth forces on the ships moored at each of the wharves in the model, and test the effects of the various development proposals on the mooring conditions at these wharves. The boundary conditions for the physical model were calculated using a mathematical model of Port Curtis which could simulate existing tidal conditions as well as the future conditions following various reclamation proposals. This paper briefly describes both models and shows how mathematical and physical models can be used in complementary roles to investigate this type of problem. (11 refs)

†**Olson, P.** 1984. Spectral model for subtidal variability in the Chesapeake Bay. Baltimore, MD: Johns Hopkins University, Department of Earth and Planetary Sciences.

The advent of long, continuous time-series records of circulation in Chesapeake Bay revealed the existence of large-amplitude fluctuations with the subtidal range 0.03 to 0.6 cycles per day. These fluctuations represent direct and indirect response of the estuary to variations in wind stress, freshwater inflow, and coastal sea level. A quantitative model is presented to explain this variability within the main stem of Chesapeake Bay in terms of a linear response to irregular, time-varying meteorological forcing. The model calculates transfer functions and energy spectra of laterally averaged transport, surface elevation, and salinity in two layers separated by a halocline, over the frequency band 0.03 to 0.6 cpd. It is found that the observed volume transport spectrum at the mouth of the bay can be explained quantitatively as the combined response to statistically independent wind stress and sea level fluctuations.

Onishi, Y., and Thompson, F. L. 1986. Sediment and contaminant transport in a marine environment. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:569-577. University, MS: University of Mississippi.

The finite element model FETRA is an unsteady, vertically averaged two-dimensional model to simulate the transport of sediment and contaminants (radionuclides, heavy metals, pesticides, etc.) in coastal and estuarine waters. The model, together with the hydrodynamic model CAFE-I, was applied to the Irish Sea to predict the migration and accumulation of sediment (both cohesive and noncohesive) and of a radionuclide (dissolved and sediment absorbed) in a tide- and wind-driven system. The study demonstrated that FETRA is a useful tool for assessing sediment and toxic contaminant transport in marine environment. (13 refs)

Orbi, A., and Salomon, J.-C. 1988. Tidal dynamics in the vicinity of the Channel Islands (Dynamique de marée dans le golfe normand-breton). *Oceanologica Acta* 11(1):55-64 (In French).

A two-dimensional mathematical model has been used to investigate tidal currents in the vicinity of the Channel Islands ("golfe normand-breton"). Attention is focused on Lagrangian and Eulerian residual components and long-term movement generation through tidal and bottom interactions. The presentation of Lagrangian velocity fields in barycentric coordinates is suggested. Results confirmed by in situ measurements (current meters and drifters) improved the knowledge and understanding of current measurement in the region. (19 refs)

Ostendorf, D. W. 1984. Linearized tidal friction in uniform channels. (See complete entry in Section I.)

Otsubo, K., and Muraoka, K. 1985. Resuspension rate function for cohesive sediments in stream. (See complete entry in Section II.)

Outlaw, D. G., and Butler, H. L. 1982. Model verification using tidal constituents. In *Proceedings of the conference applying research to hydraulic practice,* 17-20 August 1982, Jackson, MS, ed. Peter E. Smith, 674-685. New York: ASCE.

Tidal model verification using tidal constituents provides an improved technique for accurate and reliable calibration and verification of numerical tidal circulation models. The amplitude and phase of the constituent tidal surface elevation and velocity at selected stations in the estuarine area and in the open ocean remote from the influence of the estuary can readily be compared in both the model and prototype. Using verification by constituents, the model is initially calibrated for the predominant tidal constituent in the study area. The relative phase lag between stations in the model data quickly shows areas where further model calibration is required. The verification technique includes acquisition of time series tidal data (normally a minimum of 29 days), data editing, band-pass filtering to remove nontidal trends, harmonic analysis, and analysis of the data residual after completion of the harmonic analysis to ensure that all significant constituents have been included in the analysis. The technique, previously used in a limited verification of a physical model of Murrells Inlet, South Carolina, has been applied during a tidal circulation study of Lake Pontchartrain and vicinity. Tidal analysis results showed that the diurnal 0_1 and K_1 constituents have the largest amplitude in Lakes Pontchartrain and Borne and indicate that the diurnal tides in Lake Pontchartrain are co-oscillating with little change in constituent amplitude over the lake. Prototype data and model results from an implicit finite-difference model of the study area indicated excellent agreement for both the 0_1 constituent and over mean, spring, and 14-day tidal cycles. (5 refs)

Owens, N. J. P. 1986. Estuarine nitrification: A naturally occurring fluidized bed reaction? *Estuarine, Coastal and Shelf Science* 22(1):31-44.

The rates of nitrification in the water column of the Tamar River Estuary, southwest England, have been measured using the incorporation of $H^{14}CO_3$ in samples with and without the inhibitor of nitrification, 2-chloro-6-(trichloromethyl) pyridine (N_Serve). N-Serve proved successful in totally inhibiting NH_4-oxidizing bacteria, but the activity of NO_2-oxidizing bacteria was inhibited by only 30 percent; other organisms were only slightly affected. Measurements of the nitrification rate made over the entire salinity range of the estuary (0-30 percent) showed that maximum nitrification always coincided with the turbidity maximum. The field data suggest that the organisms responsible for nitrification were associated with periodically resuspended particulate material and that the turbidity maximum acts in a manner similar to a fluidized bed reactor. A dispersion model has been used to demonstrate that nitrification in the water column can account for 100 percent of the NO_2 maximum which is apparent down estuary from the turbidity maximum. (25 refs)

Özsoy, E. 1986. Ebb-tidal jets: A model of suspended sediment and mass transport at tidal inlets. *Estuarine, Coastal and Shelf Science* 22(1):45-62.

Mass transport by turbulent jets issuing from tidal inlets is investigated through a model that includes lateral mixing and entrainment, bottom friction, bathymetric changes, settling rate of particles (size), possible deposition/erosion at the bottom, and ambient currents and concentrations. The bottom frictional jet becomes diluted more slowly than a classical jet. A nonvanishing concentration may result offshore and a maximum may occur in the core. The concentration of a jet on a sloping bottom decreases more rapidly due to increased dilution by entrainment. The effects of bottom friction and bottom slope compete in determining the jet concentration. Deposition to the bottom occurs within the jet mainly on both sides of the center line, and at lower rates on the center line. Erosion or deposition may occur at the jet core depending on the inlet flow conditions. In the case of erosion at the core, the material extracted is deposited on the margins and the offshore areas. Sorting of the sediments is expected, with coarser materials mainly deposited in

the marginal areas, while the finer sediments are more uniformly distributed and jetted farther offshore. The main features of the model are verified through a limited set of observations. The qualitative agreement is enhanced for micro- and meso-tidal inlets that are dominated by tidal hydraulics. (37 refs)

Parchure, T. M., and Mehta, A. J. 1985. Erosion of soft cohesive sediment deposits. (See complete entry in Section II.)

Park, J. K., and James, A. 1986. Modeling of pollutant dispersion in stratified oscillatory flows. *Journal of Environmental Engineering*, ASCE, 112(5):921-938.

A model is presented for predicting the rate of longitudinal dispersion in nonhomogeneous oscillatory flows. The model consists of mathematical representations of velocity and salinity over a cross section and their application to the classical definition of the longitudinal dispersion coefficient. Velocity and salinity data collected over 2 years in the Tyne Estuary were analyzed for investigating principal factors controlling longitudinal dispersion. the results indicate that the model can simulate dispersive flux directly in an estuary and can be applied to a water quality model. (25 refs)

Park, J. K., and James, A. 1988. Time-varying turbulent mixing in a stratified estuary and the application to a Lagrangian 2-D model. (See complete entry in Section VIII.)

Park, Y.-H. 1986. Semidiurnal internal tides on the continental shelf off Adbidjan. (See complete entry in Section I.)

Parker, W. R. 1988. On the role of fine sediment behaviour in pollutant transfer modelling. (See complete entry in Section II.)

†**Patel, A. V., Bhatt, N. M., Partasarathy, G. S., and Modi, P. M.** 1985. Salinity distribution, pollution dispersion and tidal flushing; A case study. (See complete entry in Section III.)

Pearson, C. A., Schumacher, J. D., and Muench, R. D. 1981. Effects of wave-induced mooring noise on tidal and low-frequency current observations. (See complete entry in Section VIII.)

Pejrup, M. 1986. Parameters affecting fine-grained suspended sediment concentrations in a shallow micro-tidal estuary, Ho Bugt, Denmark. *Estuarine, Coastal and Shelf Science* 22(2):241-254.

Many shallow estuarine environments contain considerable quantities of fine-grained sediments. It is difficult, however, to determine theoretically the concentration and transport of fine-grained sediments in such environments, because the fine particles flocculate and because the suspended sediment concentration is dependent on a number of different parameters. The most important are (a) bottom shear stress (current velocity), (b) wind speed and direction, and (c) salinity. In this study the relative importance of these parameters is evaluated in relation to a shallow microtidal environment, Ho Bugt, Denmark. Furthermore, a mathematical model explaining the variation in the concentration of fine-grained suspended sediments at a station within this area was created and calibrated to measurements of wind speed and direction, salinity, and tidal current velocity. The model describes about 80 percent of the variance of the suspended sediment concentration at the observation site. (54 refs)

Perillo, G. M. E., and Ludwick, J. C. 1984. Turbulence measurements over a sand wave in Lower Chesapeake Bay, Virginia. (See complete entry in Section VIII.)

Perrels, P. A. J., and Karelse, M. 1981. A two-dimensional, laterally averaged model for salt intrusion in estuaries. In *Transport models for inland and coastal waters,* Proceedings of a Symposium on Predictive Ability, 18-20 August 1980, Berkeley, CA, ed. Hugo B. Fischer, 483-535. New York: Academic Press.

The authors trace the development formulation calibration and verification of a numerical model for the calculation of density currents in estuaries. The model is intended for three kinds of applications: as a tool for fundamental research with respect to mathematical and numerical modelling of salt intrusion in estuaries; as a alterations in estuaries with respect to tidal motion and salt concentration; and as a tool for the interpretation of phenomena and measurements from the Delft Tidal Flume. A review of existing two-dimensional laterally integrated models is also included. (37 refs)

Phien, H. N., and Vongvisessomjai, S. 1980. Mathematical modelling of surface discharge of heated water. In *7th Australasian conference on hydraulics and fluid mechanics,* 18-22 August 1980,

Brisbane, Australia, 478-479. Barton, Australia: The Institution of Engineers, Australia.

The surface discharge of heated water into a sea region is modelled by separating the tidal current from the thermal diffusion caused by the heated water, and by using similarity laws in the vertical direction for the velocity and temperature of the upper layer of warm water. A weak flow current system is generated near the outlet, and the temperature rises in a much larger area. (10 refs)

Pingree, R. D. 1983. Spring tides and quadratic friction. *Deep-Sea Research* 30(9A):929-944.

Tensors are developed for use in place of quadratic friction for the M_2 and S_2 tides. The results are used to derive the ratio of the S_2 tidal friction to the M_2 tidal friction for idealized cases and to estimate, using numerical models, a value for the ratio in nature for tidally dynamic shelf seas. It is demonstrated that the S_2 tidal friction is significantly greater than the M_2 tidal friction indicating a nonlinear frictional law. A quadratic friction law was not strictly valid when the M_2 and S_2 tides were run together in a simple spring neap simulation. However it seems that a better balance between the M_2 and S_2 frictional stress may be achieved if additional components, harmonics, and meteorological induced currents could be included. (13 refs)

Pingree, R. D., and Maddock, L. 1979. The tidal physics of headland flows and offshore tidal bank protection. *Marine Geology* 32:269-289.

The general tidal characteristics in the neighborhood of a promontory are derived using a numerical model developed in plane polar coordinates. These same tidal features are found for a model of the tides off the Start Point promontory using a Cartesian reference frame. It is shown that promontories are characterized by strong tidal flows, and it is suggested that vorticity generated near the headland plays a key role in the dynamics of offshore tidal bank formation. (19 refs)

Platzman, G. W. 1984. Normal modes of the world ocean; Part III: A procedure for tidal synthesis. *Journal of Physical Oceanography* 14(10):1521-1531.

In preceding parts of this study a set of normal modes was constructed as a basis for synthesizing diurnal and semidiurnal solutions of Laplace's tidal equations. This part describes a procedure by which such solutions can be computed as eigenfunction expansions. Since the calculated normal modes are nondissipative, it is necessary to incorporate dissipation into the synthesis procedure. This is done by a variational treatment of the tidal equations. (8 refs)

Platzman, G. W. 1984. Normal modes of the world ocean. Part IV: Synthesis of diurnal and semidiurnal tides. *Journal of Physical Oceanography* 14(10):1532-1550.

Diurnal and semidiurnal tides of second and third degree are synthesized from 60 normal modes with periods in the range 8 to 96 hr. Diurnal tides, especially those of second degree, can be represented by remarkably few modes. The principal lunar diurnal constituent, for example, consists almost entirely of a single forced mode excited mainly in the Pacific and Indian Oceans. Semidiurnals are spectrally more heterogeneous, and more resonant, than diurnals, but some specific features can be attributed to individual modes. Several of the most energetic modes in the principal lunar semidiurnal constituent are prominent in the Atlantic Ocean. Together with the fact that diurnally excited modes are relatively weak in that region, this presumably accounts for the observed tendency for the total tide to be predominantly semidiurnal in the Atlantic but mixed diurnal and semidiurnal in many parts of the Pacific and Indian Oceans. (26 refs)

Ports, M. A., ed. 1989. *Hydraulic engineering*. (See complete entry in Section I.)

Radford, P. J., and West, J. 1986. Models to minimize monitoring. *Water Research* 20(8):1059-1066.

Attempts to monitor changes in the mean concentration of pollutants in estuaries are hampered by the inherent and large seasonal variance induced by the annual pattern of river runoff. Simple models can predict this dilution effect leaving a much smaller variance against which to test for pollution events or gradual changes. An efficient method based on control charts may then be used to test for significant departures from historical performances, so enabling a relatively rapid response to be made to undesirable changes. Cumulative sum techniques may also be used to test for inconsistencies between model and calibration data leading to better prediction and therefore more sensitive control of estuarine pollution. These techniques are illustrated using salinity and dissolved cadmium data for the Severn Estuary. (9 refs).

Raney, D. C., and Youngblood, J. N. 1987. Numerical modelling of salinity propagation in Mobile Bay. In *Symposium on the natural resources of the Mobile Bay Estuary,* February 1987, Mobile, Alabama, 148-151. Mobile, AL: Alabama Sea Grant Extension Service, Alabama Cooperative Extension Service, Auburn University.

The purpose of this study was to investigate the general nature of salinity propagation in Mobile Bay, Alabama,as it is affected by river inflow levels and tidal effects. A two-dimensional depth-averaged finite difference numerical model (BAY) is utilized. This model has been demonstrated to produce salinity results that are in very good agreement with prototype values when applied to other well-mixed bays. No rigorous effort is made to verify quantitatively the solutions that were generated for Mobile Bay because of a lack of synoptic prototype data with which to calibrate and verify the numerical model. The model was simply driven with typical tidal and river inflow levels to qualitatively investigate the salinity variation over river inflow levels to qualitatively investigate the salinity variation over a tidal cycle. With the increased importance of Mobile Bay and plans to deepen the main channel, additional numerical modelling efforts are required to evaluate the environmental effect of proposed changes. However, the need for additional numerical modelling activity points out the more fundamental requirement for a synoptic data collection program in Mobile Bay to provide fundamental prototype data for a variety of scientific disciplines.

Richards, D. R. 1988. New Haven Harbor numerical model study. Technical Report HL-88-24. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

This report presents the results from a numerical model study of the impacts of deepening and widening the approach channels and inner turning basin in New Haven Harbor, CT. Results from the study were intended to determine changes in circulation, which might affect valuable oyster resources, and to form the current fields needed to provide a detailed ship simulation study of the navigation improvement project. The US Army Corps of Engineers numerical modeling system, TABS-2, was used to predict the changes that might occur to circulation patterns in New Haven Harbor and portions of Long Island Sound. Currents were predicted in the navigation channel as well as in distant shallow regions where there is a significant shellfish fishery. Results from the numerical model study indicated that there were perceptible changes in the circulation patterns but that the magnitude of the changes was very small. In most cases, base-minus-plan differences in the currents were less than 0.1 fps. The largest differences occurred in the deepened channels, away from the shallow oyster bed areas. No tide differences were detected between base and plan.

Roberts, P. J. W. 1980. Ocean outfall dilution: Effects of currents. (See complete entry in Section IV.)

Robertson, C. I., and Shellin, R. H. 1985. A model study of tidal barrage sluices for minimum energy loss. *Journal of Hydraulic Research* 23(5):453-466.

As part of the prefeasibility study for the Severn Barrage, hydraulic tests were carried out on half models of three sluice passageway designs based on a vertical gated Venturi passage. Froude law sealing relationships were used throughout, and the models were tested over a range of water levels corresponding to the expected sea level variation at the preferred barrage site. The sluices were tested under simulated in-service conditions, the flow being in one direction only, i.e., from the open sea. The quantitative results are presented as diffuser efficiency values. Flow visualization identified regions of flow separation, and measurements were also made of the downstream velocity distribution in a vertical plane. The three models tested here represent progressive modification and improvement to the original design; and their performance, as represented by diffuser efficiency, was improved from 0.55 to 0.75 and finally to 0.85. (8 refs)

Robinson, I. S. 1981. Tidal vorticity and residual circulation. (See complete entry in Section I.)

Rodrigues, A. C., da Silva, M. C., Câmara, A., Fernandes, T. F., and Ferreira, J. G. 1988. Dispersion modelling for a complex estuary--The case of the Tagus. *Water Science and Technology* 20(6/7):271-276.

Estuarine dispersion models have been commonly used to define the pollutant loads permissible to achieve predefined water quality levels and improve the knowledge of estuarine phenomena. Those models for large estuaries with complex hydrodynamic and ecological processes usually have extremely high running times. This paper presents an approach based on the use of increasingly complex models, which attempts to circumvent the problem of initial lack of data, as well as to give

some initial insight into the processes of the Tagus Estuary, within acceptable levels of precision. As a first stage, simple models were developed and applied to the estuary, one of the largest in Europe, with more than 300 sources of pollution and intensive use for recreation, fishing, and navigation. The computational exercises undertaken with these models were also used to accumulate information on the response of the Tagus Estuary to a number of forcing conditions. This information, synthesized in "if ... then" rules, was integrated to form a data base on the estuary, which is currently being developed. The data base will organize existing information and, providing that learning mechanisms are included, it will also create new knowledge, as well as supplying the complex models under development with reasonable initial values. (7 refs)

Sauvel, J. 1982. The tidal dynamics of the western North Sea. Internal Report No. 138. Merseyside, UK: Institute of Oceanographic Sciences (Unpublished Manuscript).

The currents and elevations of a coastal strip 200 x 30 miles on the east coast of England were studied. Results show significant differences between a model of single Kelvin wave propagation and the real tidal dynamics. The nonprogressive part of the tidal waves has a prevailing direction between 53 and 67 deg northeast. Simple theory can explain the observed vertical structure of tidal currents in this region. The nontidal residuals for the currents are dominated by inertial currents. Currents and elevations agree with values computed using an established numerical model. Study of the energy budget shows good agreement between the values of the energy fluxes at the boundaries, and the bottom friction dissipation, from the experiments and from the model. The energy flux balance is sensitive to small changes in the boundary interpolation schemes. (23 refs)

Savenije, H. H. G. 1986. A one-dimensional model for salinity intrusion in alluvial estuaries. *Journal of Hydrology* 85(1/2):87-109.

A salinity intrusion model for well-mixed alluvial estuaries is developed. The parameters are schematized in such a way that the amount of field work in gathering data on estuary geometry and tide is considerably reduced. The determining factor in the geometry is found to be the variation of width in the estuary. This relationship appears to obey an exponential law. The depth is found to remain fairly constant and does not necessarily have to be measured. A stationary and a nonstationary model are developed. The stationary model may be applied using a pocket calculator. In many cases, however, where the stationary model may not be used, the nonstationary model may be applied. Application of the model is demonstrated on several alluvial estuaries. (6 refs)

Savenije, H. H. G. 1988. Influence of rain and evaporation on salt intrusion in estuaries. (See complete entry in Section III.)

Scale models. 1982. *Hydro Delft* 62:14-18.

The use of scale models in estuarine studies is illustrated using two examples: the Rhine/Meuse Estuary model, used for studying salinity intrusion, and a tidal model of the Oosterschelde Delta, used in storm-surge protection studies for the Oosterschelde Barrier.

Schaffranek, R. W. 1982. A flow model for assessing the tidal Potomac River. In *Proceedings of the conference applying research to hydraulic practice,* 17-20 August 1982, Jackson, MS, ed. Peter E. Smith, 531-545. New York: ASCE.

The tidal Potomac River from the head-of-tide in the northwest quadrant of Washington, DC, to Indian Head, Maryland, including its major tributaries and tidal inlets is modeled using a generally applicable, one-dimensional, network-type, flow-simulation model. Water-surface elevations and discharges can be computed at any desired location throughout the network of channels using the model which is formulated on a weighted, four-point implicit finite-difference method. The flow model was calibrated using recorded water-surface elevations as well as measured discharges from throughout the network. The utility of the model in evaluating the flushing capability and the transport behavior of the tidal Potomac River is illustrated. The general model is a proven viable and economical flow assessment tool that is applicable to a wide range of hydrologic conditions and varying field situations. Through use of such techniques water managers and scientists involved in similar comprehensive flow assessments can certainly attain a better understanding of the interrelationship of predominant riverine and estuarine processes. (3 refs)

Schaffranek, R. W., and Baltzer, R. A. 1989. Implementation of a hydrodynamic model for the upper Potomac Estuary. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on

Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 484-492. New York: ASCE.

A vertically integrated, two-dimensional, hydrodynamic/transport model has been implemented for the upper extent of the Potomac Estuary between Indian Head and Morgantown, MD. The model computes water-surface elevations, flow velocities and time-varying constituent concentrations by numerically integrating finite-difference forms of the equations of mass and momentum conservation in conjunction with transport equations for heat, salt, and dissolved constituents. Previous preliminary calibration efforts have been extended and validity of the model implementation improved. Field-measured and model-computed water levels compare within ± 2 cm and maximum computed flood and ebb flow discharges are within 3 percent of measured values. Indications are that further improvements can be effected. The extreme channel curvature and irregular bottom configuration of the reach are factors that greatly influence the hydrodynamics and transport properties of this portion of the estuary, making this a rigorous test of both the general model and its implementation. (11 refs)

Scheffner, N. W. 1985. Investigation of tidally induced turbulent flow. Miscellaneous Paper HL-85-2. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

A two-dimensional numerical model was developed for the case of tidally induced turbulent flow. An analysis of shallow-water waves is made followed by the development of a second-order closure Reynolds stress turbulence model for the specific application to shallow-water waves. Verification of the resulting numerical model is made to existing steady-state turbulent flume data. (39 refs)

Schmalz, R. A., Jr. 1985. Numerical model investigation of Mississippi Sound and adjacent areas. Miscellaneous Paper CERC-85-2. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

This report documents a numerical investigation of Mississippi Sound and adjacent areas. A model of the complete Gulf of Mexico (GTM) is employed to develop tidal constituent (0_1 , K_1 , P_1 , M_2 , and S_2) boundary conditions for the two-dimensional vertically integrated Waterways Implicit Flooding Model (WIFM), which as extended to include salinity. In order to calibrate and verify the extended model (WIFM-SAL), an intensive data collection program was conducted by Raytheon Ocean Systems and the National Oceanic and Atmospheric Administration. Data were analyzed for tidal constituents. A global grid representing Mississippi Sound and adjacent areas was constructed to interface with the GTM grid. Bottom friction mechanics were calibrated on this global grid for 20-24 September 1980 and subsequently verified for 12-16 June 1980. A hypothetical regional dredge disposal plan was considered on the global grid by increasing the size of Sand Island. A refined grid was constructed around the Pascagoula Channel in order to study alternative channel configuration effects on Mississippi Sound. Previously calibrated and verified bottom friction mechanics were further substantiated by simulating hydrodynamic conditions for the 20-24 September period over the refined grid using global grid results to supply water-surface elevation boundary conditions. (The effects of doubling the width of the main Pascagoula Channel were then studied by simulating this same period with the modified channel.) Study conclusions are drawn and recommendations for additional simulation work are presented. In addition, horizontal salinity conditions were also investigated for the 20-24 September period. Wind speed and direction were specified as meteorological inputs. A constant drag coefficient of 0.001 was employed to develop the surface wind stress, and the friction mechanism previously developed was used to implement bottom stress. Simulation results for both the Flux-Corrected Transport and the Three Time Level Explicit schemes are presented for the global grid. Effective dispersion coefficients in each coordinate direction were calibrated. The Flux-Corrected Transport global grid salinity levels and water-surface elevation saved at the boundary of the refined grid were used to supply the boundary conditions for a Flux-Corrected Transport simulation on the refined grid. Previously calibrated global grid effective dispersion coefficients were used in the refined grid simulation.

Schmalz, R. A., Jr. 1986. Sediment transport management in the Columbia River entrance. (See complete entry in Section II.)

Schmalz, R. A., Jr. 1985. User guide for WIFM-SAL: A two-dimension vertically integrated, time-varying estuarine transport model. Instruction Report EL-85-1. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

WIFM-SAL is preliminary to the development of comprehensive water quality models that may be used to assist in the analysis of water quality

problems in shallow estuaries and embayments which may be considered vertically well mixed. The model is two-dimensional in the horizontal and generates time-varying water-surface elevations, velocities, and constituent fields over a space-staggered grid. units of measure are expressed in the non-SI system (slug-ft-second). Results computed on a global grid may be employed as boundary conditions on a more spatially limited refined grid concentrated around the area of interest. In addition, the user may select either of two distinct transport schemes. Scheme 1 is a flux-corrected transport scheme capable of resolving sharp fronts without oscillation. Scheme 2 is a full, three-time-level scheme directly compatible with the three-time-level hydrodynamics. The telescoping grid capability in conjunction with the user-selectable constituent transport scheme is an extremely powerful concept in real-world transport problem solving. (11 refs)

†**Schomaker, C. W.** 1983. A model for tidal circulation adapted to Monterey Bay, California. M.S. thesis, Naval Postgraduate School, Monterey, CA.

An implicit numerical model for two-dimensional hydrodynamic flow in coastal seas by Leendertse, as modified by Hart, was applied to Monterey Bay. The model was tested against available water level and current observations. the responses of Monterey Bay to tidal forcing and steady-state winds were simulated. Under tidal forcing it was found to provide reasonable estimates of sea surface elevations. Currents were not well predicted, indicating that other mechanisms such as wind, density stratification, and oceanic currents generally dominate the forcing of the circulation in Monterey Bay. The model in its present form was found to be potentially suitable for providing real-time tide correctors during a hydrographic survey, achieving an RMS error of 4.5 cm in predicting sea surface elevations.

Schubel, J. R., and Carter, H. H. 1984. The estuary as a filter for fine-grained suspended sediment. (See complete entry in Section II.)

†**Scott, P. J.** 1986. Sufficient conditions for optimal control of multiple basin tidal power systems. (See complete entry in Section VIII.)

Seabergh, W. C. 1985. Los Angeles and Long Beach Harbors model study; Deep-draft dry bulk export terminal, alternative No. 6: Resonant response and tidal circulation studies. (See complete entry in Section I.)

Sengupta, S., Miller, H. P., and Lee, S. S. 1981. Effect of open boundary condition on numerical simulation of three-dimensional hydrothermal behavior of Biscayne Bay, Florida. *International Journal for Numerical Methods in Fluids* 1(2):145-169.

A three-dimensional, time-dependent, free-surface model has been used to simulate the velocity and temperature distributions in Biscayne Bay, an estuarine basin in South Florida. Comparisons with tide gauge data and airborne infrared temperature data have been made. Analyses of three-dimensional velocity structure and phase relationships of velocity with depth and horizontal location have been conducted. One of the major concerns with three-dimensional models is the specification of conditions at open boundaries, since it is rare that complete time-dependent variations of variables at these boundaries are available. Two sets of approximate boundary conditions at the Biscayne Bay-Atlantic Ocean interface have been used for computations. It was found that specification of averaged surface height variation at open boundaries yields significantly better results than specification of estimated values of velocity. (21 refs)

Sheng, Y. P. 1986. Numerical modeling of coastal and estuarine processes using boundary-fitted grids. In *River sedimentation*, Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:1426-1442. University, MS: University of Mississippi.

To resolve the complex geometry and topography in coastal and estuarine environments, boundary-fitted grid technique has been incorporated into a three-dimensional, time-dependent, free-surface, finite-difference hydrodynamic model. The 3-D model combines a generalized curvilinear grid in the horizontal directions with a sigma-stretching in the vertical direction. Time-dependent hydrodynamic equations are first written in tensor invariant form, and transformed equations are then derived in terms of the contravariant vector components in the uniformly-spaced and time-invariant computational grid. This technique, which transforms both the independent and the dependent variables, has been found to be superior than those which only transform the independent variables. The model can be used with any user-provided non-orthogonal or conformal grid. Example calculations of this model include the simulation of wind-driven and tidal circulations within irregularly shaped basin and wave diffraction/

refraction around an elliptical island. Results are compared with analytical results and results of other models. (21 refs)

Sheng, Y. P. 1986. Second-order closure modeling of turbulent flow and sediment dispersion in coastal and estuarine water. In *River sedimentation*, Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:1383-1396. University, MS: University of Mississippi.

Turbulence plays an important role in all aspects of sediment dispersion in coastal and estuarine waters. Applications of a second-order closure model of turbulent transport to model turbulent flow and sediment dispersion in coastal and estuarine waters is presented here. Discussions include vertical turbulence parameterization in a three-dimensional model, oscillatory boundary layer, complex turbulent flow, sediment-turbulence interactions, deposition and erosion, and data requirements. (17 refs)

Sheng, Y. P. 1989. Validation and intercomparison of three-dimensional numerical models of estuarine and lake hydrodynamics. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 442-447. New York: ASCE.

Three-dimensional numerical models have been developed and used to study the circulation and transport of water quality parameters in estuaries and lakes. This paper discusses two important issues concerning the use of three-dimensional models of estuarine and lake hydrodynamics. Methodology for validating a three-dimensional model is first discussed with numerous examples. The issue of objective intercomparison of models is then addressed, in view of the anticipated widespread use of three-dimensional models.

Sheng, Y. P., and Butler, H. L. 1982. A three-dimensional numerical model of coastal, estuarine, and lake currents. In *Proceedings of the 1982 Army numerical analysis and computers conference,* 3-4 February 1982, Vicksburg, MS, 531-574. ARO Report 82-3. Research Triangle Park, NC: US Army Research Office.

A mathematical model capable of simulating the three-dimensional, time-dependent currents in coastal, estuary, and lake waters is presented. Special computational features included in the model are listed: (a) a time-splitting technique which separates the computation of the slowly varying internal mode (three-dimensional variables) from the computation of the fast-varying external mode (water level and vertically integrated velocities), (b) an alternating direction implicit (ADI) algorithm for the computation of the external mode, (c) an implicit algorithm for the vertical diffusion terms of the internal model equations, (d) a vertically stretched coordinate that allows the same order of accuracy in the vertical direction at all horizontal locations, and (e) an algebraically stretched grid in the horizontal directions. These computational features lead to an efficient and versatile three-dimensional model suitable for long-term simulations. Physical aspects of the model are also discussed. Applications of the model to simulate laboratory flow, tidal currents in an open bight where an analytical solution is available, wind-driven lake currents, and tide-driven and wind-driven coastal currents are also presented. (31 refs)

Siah, S. J., and Lasch, W. D 1989. A synthetic simulation model of storm surge history and inland drainage in coastal zone areas. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed, Michael A. Ports, 780-783. New York: ASCE.

In coastal zone areas, the movement of both groundwater and surface water is heavily influenced by tidal water actions. Lowland coastal communities and cities often have serious flooding problems due to extraordinarily high tides and heavy rains during hurricane or northeaster seasons. Extreme high tides are usually caused by storm surges riding on peak astronomical tides. Therefore, the simulation of a storm surge history of a particular event becomes necessary for a cost-effective drainage system design. Using a numerical model to generate a hydrograph is very costly and time-consuming and, therefore, infeasible for most small-scale community projects. In this paper, a synthetic storm surge model is proposed. With the input information of peak surge height, storm duration, and shape coefficients, this model is capable of simulating most storm events with reasonable hydrograph results. (3 refs)

†**Sivakumaran, K.** 1989. Selection of modeling and monitoring strategies for estuarine water quality management. Ph.D. diss., Colorado State University, Fort Collins.

Estuarine water quality management is challenging

owing to the complex hydrodynamics, water quality kinetics, international and domestic legislation, and human impact that take place in an estuarine environment. Scientists respond to this challenge by "observing, hypothesizing and predicting" the behavior of the estuary. This is accomplished via developing water quality models which are idealizations of the behavior and by water quality monitoring. As most of the water quality models were developed for research, they did not serve the purposes of management. Because scientific methods were not widely known, the direction by the US Congress to collect water quality data led to nonscientific methods of collecting data. The research (with the objective of using water quality models effectively) embarked on designing a water quality monitoring system using a model. A model based on the hypothesis of conservation of mass was expressed as a one-dimensional convective diffusion equation. The convective-diffusion equation was then solved recursively. Field observations from the Potomac Estuary were obtained from Government agencies and reports. An algorithm developed by Kalman was used to combine the model predictions and field measurements. In order to design the monitoring system the term "Trace of Estuary" (TOE) was defined. The relative value of TOE determined the optimum number of sampling locations for an ongoing water quality monitoring program. The approach resulted in the reduction of sampling locations in the Potomac Estuary from 12 to 5. It also showed that water quality data must be representative of similar sized segments. The concept of using the physical behavior of the system to design a water quality monitoring network was established. It was further established that the use of "better and accurate" models (not necessarily complex models) will reduce the number of sampling points. The significance of the research is that (a) modeling and monitoring are used in an integrated fashion; (b) a scientific approach is used to determine the number of sampling locations; and (c) an accurate model will lead to a reduction in the sampling locations necessary for water quality management.

†**Sklavidis, A. I., and LimaBlanco, W. R.** 1985. Coastal erosion along Monterey Bay. M.S. thesis, Naval Postgraduate School, Monterey, CA.

Permanent beach erosion in southern Monterey Bay, CA, is episodic, occurring infrequently when high tides coincide with stormy weather which allows wave action to erode the toe of the cliffs. This thesis uses precise aerial photogrammetric techniques to measure cliff recession from 1946 through 1984. Maximum erosion occurs in the vicinity of Fort Ord (7.3 ft/year) and decreases to the south. A model is developed to predict cliff erosion based on the hypothesis that erosion occurs only when the water level due to combined tides and wave setup and runup exceeds the cliff elevation. The model combines predicted tidal elevations and wave heights. Shallow-water wave heights at various locations are calculated by transforming deep water directional wave spectra provided by the Fleet Numerical Oceanography Center. Refraction of the wave energy is responsible for the variability of erosion rates along the shore. The bathymetry of Monterey Bay is such that the refracted wave energy is greater in the Fort Ord area than to the south. The erosion model was calibrated using the spectral wave climatology and aerial photographs covering an 18-year period. The model qualitatively replicates the temporal variability of the measured recession rates and gives a reasonable prediction of the spatial variation of the mean recession rates.

Smith, L. H., and Cheng, R. T. 1987. Tidal and tidally averaged circulation characteristics of Suisun Bay, California. *Water Resources Research* 23(1):143-155.

Availability of extensive field data permitted realistic calibration and validation of a hydrodynamic model of tidal circulation and salt transport for Suisun Bay, California. Suisun Bay is a partially mixed embayment of northern San Francisco Bay located just seaward of the Sacramento-San Joaquin Delta. The model employs a variant of an alternating direction implicit finite-difference method to solve the hydrodynamic equations and an Eulerian-Lagrangian method to solve the salt transport equation. An upwind formulation of the advective acceleration terms of the momentum equations was employed to avoid oscillations in the tidally averaged velocity field produced by central spatial differencing of these terms. Simulation results of tidal circulation and salt transport demonstrate that tides and the complex bathymetry determine the patterns of tidal velocities and that net changes in the salinity distribution over a few tidal cycles are small despite large changes during each tidal cycle. Computations of tidally averaged circulation suggest that baroclinic and wind effects are important influences on tidally averaged circulation during low freshwater-inflow conditions. Exclusion of baroclinic effects would lead to overestimation of freshwater inflow by several hundred m^3/sec for a fixed set of model boundary conditions. Likewise, exclusion of wind would cause an

underestimation of flux rates between shoals and channels by 70-100 percent. (19 refs)

Smith, P. E., ed. 1982. *Proceedings of the conference applying research to hydraulic practice.* (See complete entry in Section I.)

Smith, T. M. 1986. Corpus Christi inner harbor shoaling investigation. (See complete entry in Section V.)

Snyder, R. L., Sidjabat, M., and Filloux, J. H. 1979. A study of tides, setup and bottom friction in a shallow semi-enclosed basin; Part II: Tidal model and comparison with data. *Journal of Physical Oceanography* 9(1):170-188.

This is the second in a series of papers reporting the results of a study of tides, setup, and bottom friction in the Bight of Abaca, Bahamas. The extensive field data reported in Part I of the series are compared with tidal computations using a modified elliptic model first developed by Sidjabat. This model, a multiconstituent generalization of the "harmonic method" of Dronkers, is based on a polynomial representation for the magnitude of the current which provides a tractable resolution of bottom friction, resulting in a coupled set of time-independent equations governing the individual constituents. This resolution naturally splits the bottom friction into a part which can be treated as multilinear source terms on the right-hand side. The contribution to the left-hand side is large enough that the resulting coupled set may be solved iteratively, converging rapidly. The method provides an efficient and physically transparent alternative to time-stepping methods, particularly for parameter studies such as that described in the paper. Comparison of model computations with the Bight field data supports the following conclusions. (a) Bottom friction is important to the dynamics of all tidal constituents; it is the source of the M6 overtide. (b) The M4 and M6 overtides are locally generated. (c) While it is possible to fit the principal tides and the M4 overtide with quadratic bottom friction (using a constant drag coefficient and neglecting the contribution of nontidal motions to the rms current), it is not possible to simultaneously fit the M6 overtide. The resulting frictional interaction is too strong a source of the overtide (by about a factor of 2). (d) The addition of linear bottom friction (and corresponding reduction of the quadratic friction) allows an acceptable fit to both the principal tides and the M4 and M6 overtides. (e) Inclusion of a nontidal contribution to the rms current also allows an acceptable fit to both the principal tides and the M4 and M6 overtides. The necessary rms nontidal current (~ 0.28 m s^{-1}) is, however, somewhat larger than seems reasonable. (f) In either case the implied bottom stress is significantly larger than reported by other investigators. (21 refs)

†**Spaulding, M. L., and Gordon, R. B.** 1982. A nested numerical tidal model of the southern New England Bight. *Ocean Engineering* 9(2):107-126.

A nested, barotropic numerical tidal model has been applied to the southern New England Bight to include Long Island Sound (LIS), Rhode Island Sound (RIS), Buzzards Bay (BB), and a portion of the southern New England shelf. An explicit finite difference representation of the two-dimensional vertically averaged equations of motion and continuity, employing forward time and centered spatial differences with the bottom friction term being evaluated at both time levels, is applied to the study areas to predict tidal circulation dynamics. Horizontal friction and advective terms have been neglected. Tidal height data along the open boundaries are specific from available data. Model predictions of corange and high and low cophase lines agree with available data and show the strongly cooscillatory behavior of LIS. Tidal current ellipses agree reasonably well with available data showing rectilinear motion in LIS and BB and rotary motion in RIS.

Stacey, M. W. 1985. Some aspects of the internal tide in Knight Inlet, British Columbia. (See complete entry in Section I.)

Stacey, M. W., and Zedel, L. J. 1986. The time-dependent hydraulic flow and dissipation over the sill of Observatory Inlet. *Journal of Physical Oceanography* 16(6):1062-1076.

The time-dependent hydraulic flow over the sill of a tidally energetic fjord, Observatory Inlet, British Columbia, is studied. Acoustic observations of streamlines and velocity were made near the sill crest during the summer of 1982, a time when freshwater runoff into the inlet had created a distinct surface layer. While the tide was accelerating, a simple, three-layer, hydraulic model accurately simulated the flow near the sill crest. However once the tide began decelerating, the observed flow underwent a transition which the three-layer model could not explain. It was estimated that during the period of observation the hydraulic flow utilized only about 50 percent of all the energy removed from the barotropic tide. This suggests that other processes,

such as the internal tide, are removing most of the energy from the barotropic tide. (23 refs)

Stelling, G. S., Wiersma, A. K., and Willemse, J. B. T. M. 1986. Practical aspects of accurate tidal computations. *Journal of Hydraulic Engineering,* ASCE, 112(9):802-817.

Alternating direction implicit (ADI) methods are widely used for the approximation of shallow-water equations. For calibration the size of the time-step is often based upon the so-called propagation factor. This factor gives only a minor indication of the numerical propagation speed of the tidal wave. It is shown that the numerical propagation speed depends entirely on the geometry and the bathymetry combined with the spatial grid size and the time-step. Another factor that influences the propagation of the tidal wave in a computational model is the numerical simulation of intertidal flats. Numerical examples are given. (8 refs)

†**Stelling, G. S., Willemse, J. B. T. M., and Rozendaal, A.** 1986. A computational model for shallow water flow problems on the Cyber 205. *Supercomputer* 11:35-49.

Mathematical models are a basic tool for water management problems. This contribution deals with the vectorization of an implicit numerical method for the simulation of water flow in rivers, estuaries, and coastal seas. Ways to obtain contiguous vectors, necessary on the Cyber 205, for the equations, and vectorizable methods to solve tridiagonal systems are described. Comparisons of the computing effort with and without vectorization are given. (4 refs)

Su, T. Y., Trujillo, J., Yue, J. P., and Wang, S. Y. 1986. Multilevel finite element simulation of sediment transport in Mobile Bay. (See complete entry in Section II.)

Swain, A., and Houston, J. R. 1985. A numerical model for beach profile development. *Canadian Journal of Civil Engineering* 12(1):231-234.

A time-dependent numerical model that calculates beach profile development due to offshore sediment transport is developed. The model allows variable wave conditions, water level fluctuations due to tide, arbitrary bathymetry, and sediment size. The accuracy of the model is tested by comparison of calculations with laboratory and with field data. The agreement between calculated and measured beach profiles is good. (7 refs)

†**Swanson, J. C.** 1986. A three dimensional numerical model system of coastal circulation and water quality. Ph.D. diss., University of Rhode Island, Kingston.

A three-dimensional numerical model system has been developed for coastal circulation and water quality applications. The model system is composed of a hydrodynamic model component and a pollutant transport model component. The hydrodynamic model solves the conservation of momentum, water mass, salt, and heat on a space-staggered grid system. The solution technique employs a split mode semi-implicit algorithm fr both the exterior vertically averaged flow and the interior vertical structure. This technique eases the time-step restriction typical of explicit algorithms yet is more efficient than fully implicit algorithms. The model has been tested against analytical solutions for a standing wave in a closed basin, tidal and wind flow in a basin with variable depth, wind flow in a closed basin, and density forcing in a channel. Simulations show good agreement with the analytic solutions. A companion pollutant transport model has also been developed. This model, in a vertically averaged mode, was applied to upper Narragansett Bay to predict levels of fecal coliform under various pollutant loadings. The required hydrodynamic data were model generated from the M_2 and M_4 tides plus mean river flows emptying into the area. Comparison of model tidal response with observations was good. A parametric study of dispersion rate, decay rate, and source strength was undertaken to calibrate the model to known levels of fecal coliform in upper Narragansett Bay. Applications included simulation of two storms of varying intensity under conditions of no combined sewer overflow (CSO) control and full CSO control. A third storm of larger intensity was used to examine a range of CSO controls to establish their relative benefit in terms of reduced fecal coliform concentration levels. An extension of the basic model approach was developed using boundary fitted coordinates as opposed to a square finite difference grid. This technique uses a transformation such that all boundaries are coincident with coordinate lines. The solution methodology is the same as the square grid model. The model has been tested in a two-dimensional model against analytic solutions for a standing wave in a closed basin, tidal flow in an annular basin with constant depth, and wind-driven flow in an elliptic cylindrical basin. Three-dimensional tests of the code include wind and density forcing in a rectangular basin. All simulations show excellent agreement with the analytic solutions.

Tang, Y., and Tee, K.-T. 1987. Effects of mean and tidal current interaction on the tidally induced residual current. *Journal of Physical Oceanography* 17(2):215-230.

A weakly nonlinear depth-dependent tidal model has been developed to study the effects of mean and tidal current interaction on the tidally induced residual current. The model is applied to the northern and southern sides of Georges Bank. The weakly nonlinear approximation is reasonable for the southern section, but only marginally applicable to the deep water area of the northern section. For the depth-averaged tidal current, only the amplitudes of the along-isobath component are significantly affected by the interaction. The effects on the amplitudes decrease from the surface. For the cross-isobath tidal current, its changes in the upper portion of the water column generally correspond positively with the change in the along-isobath tidal current, and those in the lower portion correspond negatively. The mean and tidal current interaction increases the along-isobath residual current near the deep ends of both sections and in most of the shallow portion of the southern section. Although the effects of the interaction on the along-isobath residual current are small, a condition required for the validity of the weakly nonlinear approximation, the effects on the cross-isobath residual current are found to be very significant in many areas. This is because the cross-isobath residual component is generally an order of magnitude smaller than the along-isobath residual component; thus a small change in the latter component can generate a significant change in the former component. The increase/decrease in the along-isobath residual current due to the interaction is found to increase the onbank/offbank flow in the upper portion of the water column and the offbank/onbank flow in the lower portion. The overall response of the residual current to the interaction is qualitatively the same for different values and forms of the vertical eddy viscosity. The response of the depth-averaged residual current to the interaction is also insensitive to the depth-dependent structure of the tidal and residual current. Dynamic interpretations for various effects of the mean and tidal current interaction on the tidal and residual currents are presented. (26 refs)

Tee, K.-T. 1985. Depth-dependent studies of tidally induced residual currents on the sides of Georges Bank. *Journal of Physical Oceanography* 15(12):1818-1846.

Using a depth-dependent tidal model, the tidally induced residual currents on the northern and southern sections of Georges Bank are computed, and the effects of various physical parameters on the current are examined. Because of significant on bank Stokes drift, the rigid lid approximation is not appropriate for the shallow region of the southern section. Also, in the same shallow region, the curvilinear structure of isobaths significantly increases the on/off bank residual flow in the lower/upper portion of the water column, and thus enhances the upwelling near the shallow end of the section. Although the amplitudes of the residual current and the center of gyres in the crossbank circulation vary significantly with the values and forms of the vertical eddy viscosity and the stratification in the water column, the overall residual circulation is generally insensitive to these physical parameters. The only exception is that, for a sharp density front or a large horizontal variation in the vertical eddy viscosity, an additional tidally forced crossbank Lagrangian gyre can be induced in the middle portion of the northern section. In comparison to the wintertime tidally induced residual currents, the summertime crossisobath residual gyres are generally stronger and extend over larger areas, especially toward the shallow portion of the bank. In stratified cases, the crossbank Eulerian residual current near the frontal region of the northern section can be very significant (up to $\approx$ 7 cm sec^{-1}_. The computed alongbank residual currents are generally consistent with the observations. However, the strong onbank residual current ($\approx$ 0.7 cm sec^{-1}) at 75 m of Station A on the southern section, which is estimated from the observed low-frequency modulation of residual current, cannot be reproduced by the model. (34 refs)

Tee, K.-T. 1981. A three-dimensional model for tidal and residual currents in bays. In *Transport models for inland and coastal waters,* Proceedings of a Symposium on Predictive Ability, 18-20 August 1980, Berkeley, CA, ed. Hugo B. Fischer, 284-309. New York: Academic Press.

Simulations of three-dimensional tidal currents in a sea or basin with irregular coastlines have usually involved a three-dimensional numerical model. However, this type of computation is expensive and time-consuming and has poor vertical resolution because of limitations in computer time and storage. In this paper, a method for computing the three-dimensional structure of the first-order oscillating current and second-order tidally induced residual current is presented. The method, in comparison to the three-dimensional numerical model, is relatively

simple and efficient, does not involve a large amount of computer time and storage, and provides accurate solutions, especially near the bottom. (16 refs)

Tee, K-T., and Lim, T.-H. 1987. The freshwater pulse--A numerical model with application to the St. Lawrence Estuary. *Journal of Marine Research* 45(4):871-909.

The freshwater pulse, characterized by a salinity minimum, has been observed in many coastal areas. A two-dimensional numerical model was developed to investigate the laterally averaged estuarine circulation and the freshwater pulse in the St. Lawrence Estuary. The effects on the circulation and salinity of various parameters, including vertical eddy coefficients, river runoff, the bottom friction coefficient, and the open boundary condition were studied. The freshwater pulse in the St. Lawrence Estuary was simulated using a seasonal variation of the freshwater runoff. In addition to simulating the downstream propagation and the reduction of the pulse's amplitude toward both the ocean and the deep water in most of the areas, several interesting results were produced. These include (a) the finding of the maximum and minimum amplitudes of the pulse, (b) the increase of the amplitude from surface to deep water in the far upstream region, (c) the initial formation of the pulse at two surface locations, (d) the increase of the arrival time from surface to deep water, and (e) the increase of the arrival time for deep-water pulses (at 25 m or deeper) toward the slope region where the upstream shallow water and the downstream deep water separate. The responses of the horizontal and vertical velocities to the freshwater pulse were described. Dynamics associated with the distribution, formation, and propagation of the pulse were discussed. (25 refs)

Teeter, A. M., and Hauck, L. M. 1989. An ongoing investigation of residual suspended material transport in central San Francisco Bay, CA. (See complete entry in Section VIII.)

Teisson, C., and Latteux, B. 1986. A depth-integrated bidimensional model of suspended sediment transport. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:421-429. University, MS: University of Mississippi.

A two-dimensional, depth-integrated, finite difference model was developed in order to represent transport of well-mixed cohesive sediments in coastal water and estuaries. Simulated physical processes are deposition, erosion, and consolidation of the bed. Verification of the model was made on a case where the analytical solution is known, and a hypothetical problem of siltation in a harbor was run in tidal conditions. (6 refs)

ten Brummelhuis, P. G. J., de Jong, B., and Heemink, A. W. 1988. Stochastic dynamic approach to predict water levels in estuaries. *Journal of Hydraulic Engineering,* ASCE, 114(11):1339-1358.

A method is presented to predict water levels in tidal estuaries using Kalman filtering techniques. The method is illustrated by predicting the water levels in the Eastern Scheldt. This estuary appears to contain many of the features inherent in modeling flows in estuaries. It is seen that, although the geometry is very complicated due to numerous gullies and banks, a very simple schematization is sufficient. Furthermore, it is shown that nonlinear effects in the mouth due to the complicated geometry and the interaction between the tidal wave along the coasta and the water movements in the estuary can be compensated by using stochastic dynamic methods applied to internal boundary conditions. (25 refs)

Thabet, R. A. H., Verboom, G. K., and Akkerman, G. J. 1985. Two dimensional modelling of tidal motion for harbour studies. In *International conference on numerical and hydraulic modelling of ports and harbours,* 23-25 April 1985, Birmingham, England, ed. J. H. Pounsford, 23-32. Cranfield, Bedford, England: BHRA, The Fluid Engineering Centre.

This paper presents a discussion on various applications by the authors of two-dimensional tidal models in harbor studies. The choice of the grid size and extent of the model depends on various factors such as geographic and bathymetric conditions, main dimensions of the harbor, and (anticipated) effect of the structure on the overall tidal motion. Another important aspect which the investigator has to decide upon is the type of boundary conditions (water level or current velocity/discharge). This is in relation to the size of the area modelled and the inevitable inaccuracies of field measurements. The boundary conditions problem often leads to the application of nested models. The simulation of (large-scale) horizontal eddies is an important result of tidal studies for ports and harbors. It takes more than just the presence of the convective and turbulent diffusion terms in the governing equations to correctly

reproduce these eddies in the mathematical model. For this purpose, a careful selection is required of the grid size, time-step, values, and formulation of the (horizontal) momentum diffusion term. In some cases, a rather sophisticated expression of this term, e.g., a k-ϵ model, is necessary. (7 refs)

Thomas, W. A., and McAnally, W. H., Jr. 1985. User's manual for the generalized computer program system: Open-channel flow and sedimentation, TABS-2; main text. Instruction Report HL-85-1. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

TABS-2 is a generalized numerical modeling system for open-channel flows, sedimentation, and constituent transport. It consists of more than 40 computer programs to perform modeling and related tasks. The major modeling components--RMA-2V, STUDH, and RMA-4--calculate two-dimensional, depth-averaged flows, sedimentation, and dispersive transport, respectively. The other programs in the system perform digitizing, mesh generation, data management, graphical display, output analysis, and model interfacing tasks. Utilities include file management and automatic generation of computer job control instructions. TABS-2 has been applied to a variety of waterways, including rivers, estuaries, bays, and marshes. it is designed for use by engineers and scientists who may not have a rigorous computer background. (3 refs)

Thompson, G., Neville-Jones, P., and Shahabudin, S. M. 1984. Modelling estuaries for water resources studies. In *Proceedings of the Fourth Congress of Asian and Pacific Regional Division of the International Association for Hydraulic Research,* 11-13 September 1984, Chiang Mai, Thailand, I:509-521. Bangkok, Thailand: International Association for Hydraulic Research, Asian and Pacific Division.

The water supply in many coastal areas is obtained from abstractions in the upper reaches of nearby estuaries. An understanding of the timewise variations in water quality is necessary in order to design such intakes. Mathematical modelling presents the best way of predicting water quality and is essential if the full potential of an intake is to be safely utilized. This paper illustrates the use of such models by their application in the water resource development studies for the Kuantan region, on the east coast of Malaysia. (2 refs)

Thompson, J. F., and Johnson, B. H. 1986. Generation of adaptive boundary-fitted coordinates for use in coastal and estuarine modelling. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:1397-1406. University, MS: University of Mississippi.

Most coastal and estuarine systems that have problems requiring numerical hydrodynamic and transport modeling contain winding navigation channels. Accurate and efficient modeling of flow and suspended sediment transport requires a numerical grid that follows the navigation channel with a fine grid spacing in the channel, while retaining a larger spacing in the remainder of the field. A computer program called WESCORA has been developed to enable the numerical computation of such boundary-fitted grids for use in the finite difference modeling of flow and constituent fields. An adaptation mechanism based on a variational principle is employed. With the variational approach, a functional that consists of the sum of three integrals involving the physical coordinates is minimized over the grid. The first of the integrals controls grid point concentration by forcing the grid points to cluster where the water depth is large, i.e., in navigation channels. The other two integrals control grid smoothness, i.e., the rate of change of grid spacing and the skewness of the coordinate lines. By weighting the importance of the three integrals, either grid point concentration, grid smoothness, or orthogonality can be emphasized. (7 refs)

Thorn, D. B., and Guganesharajah. 1986. Flood protection and drainage of the East and West Fens unsteady flow modelling studies. In *Hydraulic design in water resources engineering: Land drainage,* Proceedings of the 2nd International Conference, April 1986, Southhampton University, UK, ed. K. V. H. Smith and D. W. Rycroft, 213-220. Berlin: Springer-Verlag.

The East and West Fens cover about 40,000 ha with large parts of the area at or below sea level, and are drained by a complex system of interconnected channels. Companion papers describe hydrological studies and studies of engineering and economics. This paper is confined to unsteady flow modelling studies aimed at evaluating the hydraulic performance of alternative development options. Some of the development options could be compared using simple backwater analyses and cost estimates. Others required use of an unsteady-state computational model to account for the effect of channel storage in attenuating flows in the drainage system, in

conjunction with alternative outfall capacities and a possible offstream storage site. The model described is flexible in use and allows closed loops in the drainage system, where water can drain via more than one route to a common point. Boundary conditions include the options of pumping or gravity discharge to a tidal river estuary. (3 refs)

Thouvenin, B., and Salomon, J.-C. 1984. Three-dimensional model of circulation and dispersion in a tidal coastal area (Modèle tridimensionnel de circulation et de dispersion en zone côtière à marée). *Oceanologica Acta* 7(4):417-429 (In French).

In order to reproduce and investigate the marine circulation in the coastal tidal zone, and especially its three-dimensional nature, it appeared interesting to develop a numerical model which could take account of the real bottom topography and the variations of the free surface. Navier-Stokes equations are solved in a straightforward manner, generalizing a finite difference technique already used in two-dimensional vertical models. To test the computational program, the model was applied to a number of lat bottom schematic basins, where wind-driven currents and tide propagation were reproduced. Then the particular case of real channel and, finally, density currents associated with a salty wall were considered. Model results are compared to theoretical solutions (amphidromic point, Ekman spiral) or results obtained from other models. The first attempt to apply the model to a real area was for the Bay of Seine. Although certain specific points in the numerical scheme could be improved, results seem favorable, and show that the model reproduces quite well the different physical phenomena of interest in coastal areas. (21 refs)

Tomasello, R. S., and Ortel, T. W. 1989. Cocohatchee River basin study. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 717-722. New York: ASCE.

The Cocohatchee River discharges to estuarine tidal waters of the Gulf of Mexico. While the river basin has been substantially altered by man-made drainage works, development is relatively sparse. Some of the most important ecological wetland assets to southwest Florida, including Corkscrew Swamp, drain to the Cocohatchee. Flood protection for the expected rapid future development must be tempered with the necessary safeguards of these environmental qualities as well as water supply considerations. A thorough understanding of the hydrologic, hydraulic, and hydrodynamic characteristics of the system is essential for appropriate planning and design. The report presents the modeling of the Cocohatchee River basin, including two-dimensional routings for wetland regimes, hydrologic/Hydraulic analyses of the agricultural and suburban land uses, and the dynamic wave channel routine (DWOPER, 1984 version). The variety of models were incorporated to simulate the interaction between backwater effects, discharge from developed and undeveloped sub-basins, and downstream tidal boundary conditions. The models were calibrated and verified to existing hydrologic and hydraulic conditions with the intent to evaluate future proposed water management alternatives. (4 refs)

Toorman, E. A., and Berlamont, J. E. 1989. Estuarine mud flow modeling. (See complete entry in Section V.)

Tran, D., and Merveille, J. 1986. The problem of brackish water intrusion into inland waterways--The French wateringues area. (See complete entry in Section III.)

Tsai, C.-H., and Lick, W. 1988. Resuspension of sediments from Long Island Sound (U.S.A.). *Water Science and Technology* 20(6/7):155-164.

Resuspension experiments were conducted in seawater in an annular flume on fine-grained sediments from Long Island Sound. From these experiments, the resuspension rates and the sediment concentrations at steady state were quantitatively determined as a function of shear stress and bed compaction. In addition, net resuspension experiments were conducted. From these, the total amount of sediment that could be resuspension rate decreased with time, and the total amount of sediment that could be resuspended at a constant shear stress approached a constant value as time increased. This demonstrates a major difference between the resuspension characteristics of fine-grained sediments and those of uniform-size, coarse-grained, noncohesive sediments. For the latter case, the resuspension rate ideally would be constant with time. Resuspension experiments were also conducted with deposit-feeding Nucula clams seeded into the sediment bed. In all cases, the steady-state concentrations as a function of shear stress were significantly greater than those in tests without Nucula. The tests also suggest that after sediments are seeded with Nucula for approximately 7 days, the sediment resuspension does not change with time of consolidation. (7 refs)

Tsay, T.-K. 1989. Verification of local modes in a two-dimensional tidal model. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 428-433. New York: ASCE.

Based on a generalized model equation, a two-dimensional, hybrid, finite element model has been developed to study tidal waves of incompressible, homogeneous fluid in rotational flows. In this paper, the present model is verified for tidal waves around a circular island on a paraboloidal slope. Numerical solutions are compared with analytical results for both propagating and decaying modes. The present model is shown to be an accurate method for the solutions of tidal flows. (9 refs)

Ukita, M., Nakanishi, H., and Sekine, M. 1988. Study on transport and material balance on nutrients in Yamaguchi Estuary (Japan). *Water Science and Technology* 20(6/7):199-210.

The transport and material balance of nutrients in the Yamaguchi Estuary were studied using environmental impact assessment (EIA), in order to investigate the effects of the reclamation of tidal marshes. The main methods utilized were (a) a topographical survey, (b) pollutant load analysis, (c) water sampling during one tidal cycle, (d) sediment quality analysis; (e) box model analysis of water quality, and (f) modelling of the ecological system including fish. The main results obtained were as follows: (a) after the reclamation of 348 ha, the volume of the estuary, tidal prism, and tidal marsh area decreased by 6.5 percent, 12 percent, and 11 percent, respectively; (b) pollutant loads have increased from 1.38 to 1.69 tons/day for N and from 0.09 to 0.18 tons/day for P; (c) upward transport of suspended solids (SS) was observed under fine weather conditions, especially in the summer; (d) sediments in marsh areas exhibited higher values of oxygen consumption rate and nutrient recycling rate; (e) the net settling velocity of SS in the river mouth area was 1 to 3 m/day; (f) most of the SS transported up the estuary seemed to be flocculent organic matter; and (g) the results of the box ecosystem model simulation indicated that there will be a net input of fish from the open sea area. (10 refs)

Usseglio-Polatera, J. M., and Cunge, J. A. 1985. Modelling of pollutant and suspended sediment transport with ARGOS modelling system. In *International conference on numerical and hydraulic modelling of ports and harbours,* 23-25 April 1985, Birmingham, England, ed. J. H. Pounsford, 83-92. Cranfield, Bedford, England: BHRA, The Fluid Engineering Centre.

Principles and numerical examples of the use of the ARGOS modelling system to simulate siltation and pollution of harbor and bay areas are presented. The system enables numerical integration of horizontally two-dimensional advection-diffusion equations of pollutant or suspended sediment transport. It uses the finite difference method but allows for subgrid effects such as near-outfall or suction dredging situations when the characteristic dimensions are less than computational grid spacing. Spurious numerical damping is nearly eliminated. The ARGOS system makes use of tidal or wind-induced current and elevation fields measured or computed by other systems. (7 refs)

van Rijn, L. C. 1986. Sedimentation of dredged channels by currents and waves. *Journal of Waterway, Port, Coastal and Ocean Engineering,* ASCE, 112(5):541-559.

A detailed mathematical model for sedimentation of dredged channels, based on a detailed representation of all relevant transport processes such as convection, mixing, and settling, is presented. This is an important advantage compared with the traditional prediction formulas, which are based on a rather strong schematization of the transport processes. A sensitivity analysis is presented showing the influence of the streamline refraction effect and the wave shoaling effect in the channel on the sedimentation process. Two applications of the proposed mathematical model are given and show reasonable agreement between measured and computed concentrations and sedimentation rates. Finally, a set of graphs is presented which can be used to get a rough estimate of the trapping efficiency of dredged channels. (22 refs)

Vemulakonda, S. R., Swain, A., Houston, J. R., Farrar, P. D., Chou, L. W., and Ebersole, B. A. 1985. Coastal and inlet processes numerical modeling system for Oregon Inlet, North Carolina. Technical Report CERC-85-6. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Oregon Inlet is a large tidal inlet through the barrier island system of North Carolina. In 1970, Congress authorized the Manteo (Shallowbag) Bay project which had provisions to stabilize Oregon Inlet with

two jetties, deepen the ocean bar channel to 20 ft, and bypass across the inlet sand intercepted by the jetties. This report describes the results of a numerical study to consider coastal and inlet processes in the region surrounding the inlet under existing and planned project conditions. To accomplish the objectives of the study, a system of numerical models called Coastal and Inlet Processes (CIP) Numerical Modeling System was developed. It included models for wave propagation, wave-induced currents and setup, sediment transport within and beyond the surf zone, and profile response (onshore-offshore transport). Results from a separate study on numerical simulation of tides and storm surge for Oregon Inlet were utilized in the present investigation. As a test for an extreme event, the Ash Wednesday storm of March 1962 was simulated with the profile response model. There was good agreement between the calculated erosion amounts of the shore-normal profiles for Bodies and Pea Islands (on either side of Oregon Inlet) and values measured in the field. As an alternative to the stabilization of the entrance channel by construction of two jetties, a nonstructural solution proposed by the Department of the Interior was evaluated using the profile response model. The solution involved disposal of the dredged material from the entrance channel in the near-shore region with the idea that the material would be dispersed shoreward by wave action at a rate sufficient to prevent dredging-induced beach erosion. The results of the model indicated that on the average only 25 percent of the disposed material migrated toward the shore in a year. This migration was insufficient to prevent dredging-induced beach erosion. In order to perform an ocean bar channel dredging analysis, the US Army Engineer District, Wilmington (SAW), needed to know the period of time that dredges of the CURRITUCK and ATCHAFALAYA/ MERMENTAU classes could operate in the entrance channel under the influence of waves. To study this problem, the wave propagation model was run allowing for wave-current interactions. Using the model results, SAW determined the limiting wave heights for dredging operations to be deepwater significant heights of 3.0 and 4.0 ft, respectively, for the two classes of dredges. The CIP system was used to study the erosion and accretion in the entrance channel as well as the lateral movement of the channel in the presence of the south jetty alone, simulating a construction sequence in which the south jetty was built before the north jetty. To accomplish this the longshore sediment transport model simulated an average year's wave climate and tide, using the results of the wave, wave-induced current, and tide models. The results of the simulation showed that during the year a total of 1,055,990 cu yd of material was trapped in the entrance channel, whereas a total of 660,000 cu yd of material was eroded between the southern boundary of the channel and the south jetty. It was determined that the entrance channel could move on the average about 150 ft per year toward the south jetty. (44 refs)

Vollmers, H.-J. 1986. Physical modelling of sediment transport in coastal models. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:472-487. University, MS: University of Mississippi.

This paper discusses the effectiveness of using models to solve hydromechanical problems. It tackles, in particular, the problems associated with mathematically modelling sediment transport processes, using the North Sea coast of Germany as an example. (5 refs)

Vongvisessomjai, S., and Charuskumchornkul, S. 1989. Boundary conditions of tidal model at river mouth. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 83-88. New York: ASCE.

A small grid is required to schematize the irregular shape of shoreline in the vicinity of a river mouth which limits the modeling area to be small. Tidal records along the boundary show no variation as the tides are long waves while data of currents along the boundary are in general not available. A methodology is developed in which a complementary tidal model of a sea region with larger grid is used to generate tidal currents along the open boundary for the major model. Both are two-dimensional, depth-averaged, finite difference models. This approach is successfully applied to compute circulation patterns in the vicinity of the mouth of the Chao Phraya River, Thailand. (3 refs)

Vongvisessomjai, S., and Pongpirodom, P. 1986. A laterally averaged model for estuarine sedimentation. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:453-462. University, MS: University of Mississippi.

Many famous ports of the world are situated in estuaries. Heavy shoaling in the lower part of

estuaries acts as a navigational barrier, which may have been comparatively nominal in the past for shallow-draft vessels; but with the modern deep-draft vessels, access to the ports is blocked. Thus the development of the existing ports and improvement of estuarine channels, especially in the heavy shoaling area, is necessary. Improvements of ports and navigation channels will result in a change in the existing regime of an estuary such as shoaling patterns, circulation patterns, salinity intrusion, etc. The planning of such work requires, therefore, a knowledge of estuarine dynamics, sedimentation processes, sources of sediments, and location and amount of shoaling. Hydrodynamic and sediment transport models are developed which describe the fluid circulation, distribution of cohesive suspended sediment, and sediment deposition patterns for laterally homogeneous, well-mixed, and partially mixed estuaries. The formulation of the models is based on the three-dimensional equations of continuity, momentum, and conservation of mass. After integration of the continuity and momentum equation over the width, and use of the boundary conditions, a laterally homogeneous, two-dimensional hydrodynamic model is formulated. By a similar procedure, a laterally homogeneous two-dimensional sediment transport model is obtained. In order to make the developed model as general as possible, free water surface fluctuations, irregular bed boundaries, near-bed velocity profiles, and mass balance of fine cohesive sediment at the bed are taken into account. The estuarine sediment transport is divided into various processes according to the increasing magnitude of the shear stress as deposition, transportation, and erosion or resuspension. Due consideration is made of the properties of sediment. The developed models are verified and then applied to calculate the flow field and distribution of fine cohesive sediment in the lower part of the Chao Phraya Estuary where Bangkok Port is located. The obtained results compare well with the field measurements. In other words, the complicated phenomena of estuarine dynamics and sedimentation processes can be simplified and described adequately by the models. (35 refs)

†**Walters, R. A.** 1986. A finite element model for tidal and residual circulation. *Communications in Applied Numerical Methods* 2(4):293-298

Harmonic decomposition is applied to the shallow-water equations, thereby creating a system of equations for the amplitude of the various tidal constituents and for the residual motions. The resulting equations are elliptic in nature, are well posed, and in practice are shown to be numerically well-behaved. There are a number of strategies for choosing elements: the two extremes are to use a few high-order elements with continuous derivatives, or to use a large number of simpler linear elements. In this paper simple linear elements are used and prove effective. (16 refs)

Walton, R., Bird, S., Ebersole, B., and Hales, L. 1989. Numerical model studies of wetland hydraulics for Balsa Bay, California. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 236-241. New York: ASCE.

The Balsa Bay area, near Los Angeles, California, presently consists of three distinct regions separated by two sets of culverts. The extreme interior area is a wetland which is doubly muted by the culvert systems. The tidal range in the outer bay is 6 ft, 1.5 ft in the muted inner bay, and 1 ft in the doubly muted existing wetland area. Outer Balsa Bay has one opening to the Pacific Ocean, and water that enters the inner systems passes through the development of Huntington Harbor. The wetland area also contains man-made islands which are used for oil exploration. A development is being considered, in which a balance between housing and marinas and planned wetlands is being sought. Alternatives being considered include marinas of various sizes, a second ocean entrance, modifications of the culvert systems, and plans for wetland extension and maintenance. A central part of any scheme that may be accepted is the development of the correct flushing in the interior region to support healthy wetlands. To analyze the various design alternatives, it became necessary to develop a numerical model of the existing system that could be used to examine the effect of geometry, and flows through the culvert systems. Instead, a version of the link-node Dynamic Estuary Model was modified to dynamically simulate flows through culverts under a variety of upstream and downstream heads. (4 refs)

†**Walton, R., Shubinski, R. P., and Aldrich, J. A.** 1982. A three-dimensional circulation model for Chesapeake Bay. In *Computational Methods and Experimental Measurements,* Proceedings of the International Conference, 30 June-2 July 1982, Washington, DC, ed. G. A. Keramidas and C. A. Brebbia, 529-540. South Hampton, UK: Computer Mechanics Centre.

A three-dimensional model, developed to simulate

the circulation in Chesapeake Bay, North America, and its major tributaries, is described. The model is economical, with good stability and accuracy and was designed to interlink with future water quality, sedimentation, and ecosystem models of the bay.

Wang, J. D., and van de Kreeke, J. 1986. Tidal circulation in North Biscayne Bay. *Journal of Waterway, Port, Coastal and Ocean Engineering*, ASCE, 112(6):615-631.

The hydrodynamic exchange in this barrier island lagoon that has been highly modified by dredging and causeway construction is analyzed using field measurements and numerical models. Based on the field observations, a nested numerical modeling approach is adapted to determine the tidal and wind-driven flow and circulation. The nesting of one- and two-dimensional models provides an efficient solution method without sacrificing predictive ability or resolution. Alternatives for enhancing hydrodynamic transport and circulation by modifying the geometry of the bay are evaluated and residence times for present conditions are determined. (15 refs)

Wang, J. D., Blumberg, A. F., Butler, H. L., and Hamilton, P. 1990. Transport prediction in partially stratified water. *Journal of Hydraulic Engineering*, ASCE, 116(3):380-396.

The essentials of hydrodynamic model application techniques and necessary supporting data are given for the situation of a partially stratified water body. The presentation s aimed at improving numerical predictions of tidal hydrodynamics and is oriented toward somewhat experienced modelers. To guide the modeler, the subjects covered are arranged in the order in which they ideally would be addressed during the execution of a study. These subjects fall broadly under the headings hydrodynamic classification, model selection, model adaptation, model testing and calibration, and model verification and application. Meaningful and quantitative measures are needed to establish model performance and to provide a basis for model intercomparisons and possible future setting of standards. Various quantitative measures are suggested. To encourage their use, it is recommended that providing a quantitative measure when comparing model data with observed data be a condition for publication. A number of research needs are also identified. (37 refs)

Wang, S. Y., Shen, H. W., and Ding, L. Z., ed. 1986. *River Sedimentation.* (See complete entry in Section II.)

Wang, Y. H. 1986. Deposition behavior of fine sediments in an estuarine saline wedge. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:552-558. University, MS: University of Mississippi.

Laboratory experiments on discharge of fine sediments (such as organic matters, silt, and clay) in a simulated estuarine saline wedge were performed. It was observed that only the coarse and heavy sediment particles reached the channel bottom; the fine particles were retained by the interface of the saline wedge without reaching the channel bottom. This lump of fine sediment at the interface spreads laterally at the interfacial level and generates an interfacial density current. The spreading rate and the speed of the density current were estimated experimentally. As the fine sediments spread horizontally along the interfacial level to form an interfacial layer, the entrainment between the newly formed interfacial layer and the bottom salt layer takes place. As time elapses, the entrained fine sediments penetrate through the interface and settle down on the full length of the channel bottom.

Weaver, A. J., and Hsieh, W. W. 1987. The influence of buoyancy flux from estuaries on continental shelf circulation. *Journal of Physical Oceanography* 17(11):2127-2140.

The release of fresh water from a midlatitude estuary to the continental shelf is modeled numerically as a Rossby adjustment problem using a primitive equation model. As the initial salinity front is relaxed, a first baroclinic-mode Kelvin wave propagates into the estuary, while along the continental shelf, the disturbance travels in the direction of coastally trapped waves but with a relatively slow propagation speed. When a submarine canyon extends offshore from the estuary, the joint effect of baroclinicity and bottom relief provides forcing for barotropic flow. The disturbance now propagates along the shelf at the first coastally trapped wave-mode phase speed, and the shelf circulation is significantly more energetic and barotropic than in the case without the canyon. For both the experiments with and without a canyon an anticyclonic circulation, generated by the surface outflow and deeper inflow over changing bottom topography, is formed off the mouth of the estuary. As the deeper inflow encounters shallower depth, the column of fluid is vertically compressed, thereby spinning up anticyclonically due to the conservation of potential vorticity. This feature is in qualitative

agreement with the Tully eddy observed off Juan de Fuca Strait. A study of the reverse estuary (where the estuarine water is denser than the oceanic water) shows that this configuration has more potential energy (where the estuarine water is denser than the oceanic water) shows that this configuration has more potential energy available for conversion to kinetic energy than the normal estuary. Bass Strait may be considered as a possible reverse estuary for generating coastally trapped waves. The effects of a wider shelf and wider estuary are examined by two more experiments. For the wider shelf, the resulting baroclinic flow is similar to that of the other runs, although the barotropic flow is weaker. The wide estuary model proves to be the most dynamic of all, with the intensified anticyclonic circulation now extending well into the estuary. (27 refs)

Weber, L.-Y. L., and Leidersdorf, C. 1989. Application of hydraulic and sediment transport principles in the design of tidal exchange structures. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 89-94. New York: ASCE.

This paper presents a procedure for the analysis and design of tidal exchange structures, such as tidal gates and training dikes. In lieu of overgeneralized theories or complicated modeling techniques, the procedure employs basic hydraulic and sediment transport principles to evaluate the tidal exchange and tidal inundation potentials. This includes development of Model TIGATE to simulate tidal flow dynamics and introduction of a sediment flushing index to identify the sediment flushing capability of the tidal flow. (11 refs)

Weishar, L. L., and Fields, M. L. 1985. Annotated bibliography of sediment transport occurring over ebb-tidal deltas. (See complete entry in Section II.)

Weishar, L. L., and Aubrey, D. G. 1988. Inlet hydraulics at Green Harbor, Marshfield, Massachusetts. (See complete entry in Section V.)

†**Wen, C.-G., Kao, J.-F., Wang, L. K., and Wang, M. H.** 1983. Sensitivity analysis of ecological design parameters in streams: Part B. (See complete entry in Section IV.)

West, J. R. 1983. An evaluation of a moving-coordinate system model of salinity intrusion into the Mersey Estuary. (See complete entry in Section III.)

Westerink, J. J., Stolzenbach, K. D., and Connor, J. R. 1989. General spectral computation of the nonlinear shallow water tidal interactions within the Bight of Abaco. *Journal of Physical Oceanography* 19(9):1348-1371.

An iterative frequency-time domain finite element tidal circulation model is applied to the Bight of Abaco in the Bahamas to study the nonlinear interactions that occur between the various astronomical, overtide, and compound-tide constituents. The nonlinear origin of the significant shallow-water constituents is determined by suppressing the various nonlinear terms in the shallow-water equations. Furthermore, the extent to which nonlinear constituents interact with and affect each other is studied in detail by suppressing the interaction of selected tides within the framework of the iterative frequency-time domain formulation. It is found that secondary nonlinear interactions between the astronomical tides and the shallow-water tides themselves can significantly affect overtides, compound tides, and even astronomical tides. (22 refs)

†**Wiberg, P. L.** 1987. Mechanics of bedload sediment transport, Ph.D. diss., University of Washington, Seattle.

A theoretical model of sediment motion in the bed load layer derived herein, yields detailed information about bed load mechanics for a large range of sediment types and flow conditions. The model, based on the equations of motion for a sediment grain near a noncohesive bed, includes drag, lift, gravity, and relative acceleration. Solved numerically, these equations give the path of a saltating grain, from which saltation height, length, and particle velocity can be computed; the initial conditions are determined as part of the model. heights of calculated trajectories are significantly lower and more symmetrical than available measurements would suggest unless the collisions with the bed are included in the model, in which as the calculated trajectories agree well with experimental measurements. Bed load sediment flux is the product of particle velocity and sediment concentration integrated over the bed load layer. Concentration is set by the momentum extracted from the flow by the accelerating grains, and can be found using the model. Predicted curves of bed load transport versus boundary shear stress agree well with data from Gilbert, Meyer-Peter, et al., and the Waterways Experiment Station; measured shear stress is corrected for pressure drag in cases where bed forms were present. Comparison of

predicted bed load transport with common bed load equations reveals considerable similarity among the relationships. The best agreement with the data is produced by relationships in which the transport rate vanishes as the shear stress approaches the critical value, as in this model and Yalin's equation. An algebraic equation for bed load flux, constructed from approximate expressions for saltation height, particle velocity, and sediment concentration, provides a good height, particle velocity, and sediment concentration, provides a good representation of the calculated values and has the same asymptotic form at high transport stage as the Yalin and Meyer-Peter and Müller equations. As transport stage increases, the conditions are reached for either incipient suspension or a high-concentration grain flow at the bed surface. The former is more likely for quartz-density grains less than 0.08 cm in diameter, and the latter for larger sizes. In either case, a transition is reached by a transport stage of twenty, providing the upper limit for purely bed load transport of well-sorted sediment.

Williams, B. L. 1985. Tauranga Harbour effluent dispersion modelling study. In *1985 Australasian conference on coastal and ocean engineering,* 2-6 December 1985, Christchurch, New Zealand, 2:485-493. Barton, A.C.T., Australia: The Institution of Engineers, Australia.

The application of two numerical models developed by the Danish Hydraulics Institute (S21HD and S21TD) to an effluent dispersion problem in the Tauranga Harbor is outlined. The paper focuses on the transport-dispersion modelling (S21TD) and discusses key aspects of implementing this type of model. (4 refs)

Williams, D. T., Ingram, J. J., and Thomas, W. A. 1986. St. Lucie Canal and estuary sedimentation study; Mathematical model investigation. Miscellaneous Paper HL-86-4. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

The St. Lucie Canal was constructed for flood control and other purposes in 1948. The canal connects Lake Okeechobee to the South Fork, St. Lucie River, just upstream from the St. Lucie Estuary. Following the project's construction, the canal widened and local interest reported shoaling and turbidity in the South Fork of the St. Lucie Estuary. The objectives of this numerical model study were to (a) identify the major sources of sediment causing shoaling in the South Fork, St. Lucie Estuary, (b) determine the water discharge threshold at which substantial quantities of sand begin to move in th canal, (c) forecast the expected value of future shoaling rates in the South Fork, St. Lucie Estuary, (d) determine if an over-gate release of water would produce less turbidity than the present undergate release, and (e) assess the adequacy of existing field data and recommend modifications to the data collection program as necessary. To meet these objectives, numerical models of the systems were developed. The computer code "HEC-6, Scour and Deposition in Rivers and Reservoirs," was used for the canal study area and four numerical models of the estuary were developed. Two of the estuary models analyzed shoaling and scour using field survey data. A two-dimensional hydrodynamic model was developed to investigate water current patterns. The fourth model, an HEC-6 model of the area downstream of the St. Lucie lock, was used to forecast future quantities of sand discharge into the estuary and enable a prediction of future shoaling conditions. The laterally averaged, two-dimensional model, LARM, was used to study the relative effect of overgate versus undergate releases on the vertical distribution of velocity in addressing the turbidity question.

Wilson, J. A. 1985. The influence of an artificial hydraulic regime on water quality in the tidal river Lagan, Northern Ireland. *Journal of The Institution of Water Engineers and Scientists* 39(5):423-436.

This paper outlines the nature and effects on water quality of major changes in the flow characteristics of estuarine waters in a 9-km section of the river Lagan. By analogy, it highlights the related water quality and engineering problems involved in a proposed scheme to improve both the visual appearance and recreational value of the river. Discussion is confined to the nature of the artificial flows and to their influence on the distribution of dissolved oxygen throughout the estuarine waters. (4 refs)

Wilson, P. R. 1985. Tidal studies in the One Tree Island Lagoon. (See complete entry in Section I.)

Wong, H. F. N., and Cheng, R. T. 1989. A branched hydrodynamic model of the Sacramento-San Joaquin Delta, California. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 493-498. New York: ASCE.

A new and efficient hydrodynamic model is used to simulate flows in the Sacramento-San Joaquin Delta, California. The model solves the one-dimensional

shallow-water equations for flow in a channel network using a semi-implicit finite difference method at the interior grid points and an extension of the fixed grid method of characteristics at the junctions. The two-step procedure is unconditionally stable and allows individual channel segments to be uncoupled from the channel network so that no large matrix solution is required. The paper describes the numerical details of the model algorithm and presents the results of comparing model simulations with available measurements of water surface elevations in the delta. (2 refs)

Wood, T. 1980. Mixing in an unsteady flow system. In *7th Australasian conference on hydraulics and fluid mechanics,* 18-22 August 1980, Brisbane, Australia, 541-544. Barton, Australia: The Institution of Engineers, Australia.

A method for measuring and characterizing the degree of mixing in an unsteady flow system is tested and found to be satisfactory. Previous concepts developed for steady flow systems are extended to the unsteady flow case. Mathematical relationships are worked out which permit the calculation of limiting values of the degree of mixing, as expressed by the "holdback" parameter. An experimental method determining the "holdback" parameter is outlined and experimental results are reported to illustrate the way in which the degree of mixing in an unsteady flow system is influenced by the inlet and exit flow rates, and the internal configuration of the flow system. (4 refs)

†**Wu, T.-S.** 1987. Direct computation of tidal circulation in harbors. Ph.D. diss., North Carolina State University at Raleigh.

Awareness of the effects of tidal circulation is very important for the harbors' environmental protection, planning, and design. To understand the tidal circulation effects in harbors, this study has developed a verified numerical model to predict the water elevation and averaged velocity field in rectangular harbors. The time-dependent nonlinear equations of motion and continuity are integrated over the water depth. The numerical properties of the simplified set of the integrated equations allow the finite difference method to be selected. This study introduces a new numerical model--an implicit finite difference method with a space-staggered scheme. using the linearized analytical solution and nonlinear perturbation method to verify the new numerical model, the agreement has been satisfactory by the following sensitivity parameters--time-step, bottom friction, bathymetry, Coriolis force, nonlinear terms, harbor's dimensions, and specified amplitude at the opening.

Wu, T. S., and Janowitz, G. S. 1989. An analytical solution to verify a nonlinear tidal circulation model. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 479-483. New York: ASCE.

Many numerical models have been applied to tidal circulation problems. Most numerical models are demonstrated by comparison of computed variables with field observations, experimental data, or linearized analytic solutions. Nonlinearities in tidal circulation equations are difficult to handle mathematically. No exact solution has been published which can be used as a tool for numerical model verification. The accuracy of existing numerical model solutions are therefore generally not completely known. This study introduces an analytic solution as an example to verify the nonlinearities of numerical models. (1 ref)

Young, C. L., Weisman, R. N., and Lennon, G. P. 1988. Modeling deposition of suspensate in Great Sound, New Jersey. *Marine Geology* 82(1/2):49-60.

A sediment deposition model is developed for application to Great Sound, New Jersey. A determination of the average annual accumulation rate is of primary interest. The settling tank concept is used for the model, employing a plug flow approach to model the tidal hydrodynamics. Assumptions inherent in this modeling technique include no mixing between plugs, a uniform vertical velocity profile, and simplified geometry. Model inputs were based on hydrodynamic and suspended sediment data obtained for Great Sound during other investigations, including initial volume in the sound at mean low water, the inflow hydrograph and tidal range, the sediment sizes, concentrations and settling velocities, and a frequency versus concentration relationship. The model simulates a single tidal cycle in Great Sound for spring, neap, or mean tidal conditions for a specified sediment concentration. Three tests were run to define the sediment deposition characteristics of the sound. The first test defined the relative impact of spring, neap, and mean tidal ranges on the deposition. Deposition during mean tide was defined the relative impact of spring, neap, and mean tidal ranges on the deposition. Deposition during mean tide was found to be the average of the spring and neap tide deposition. Concentration hydrographs for ebb flow were determined. The second test

determined the average annual sediment accumulation rate in Great Sound to be 8.9 mm/year by running multiple tidal cycles for fair, pre- and post-storm, and storm conditions. Model predictions compare favorably with prediction of other researchers. The distribution of the average annual accumulation across Great Sound is also defined. In the third test, the relative influence of storm conditions versus predominant fair-weather conditions was established. Only eight storm days are required to match a year of fair-weather deposition. (20 refs)

†**Zasinska, E., and Robakiewicz, W.** 1988. Hydrodynamic conditions and salinity of the Swina Strait and the Szczecin Bay. (See complete entry in Section III.)

†**Zhang, Q.** 1985. The interaction between estuarine plumes and continental shelf waters. Ph.D. diss., North Carolina State University at Raleigh.

A simple analytical model is developed to describe the steady flow in an estuary-shelf interaction region where the water is treated as a two-layer density-stratified flow. The motion is expanded in terms of the relative thickness of the Ekman layer, $E_v^{1/2}$. The order-zero flow is geostrophic in each layer. Balancing of order-one quantities reduces the system to two vorticity equations relating the pressure field with the displacement of the interface and the bottom topography. An explicit solution is obtained for the case of linear offshore sloping bottom. The flow behavior of the river water plume depends on the vertical structure of the flow at the river mouth, the bottom topography, and the ambient coastal flow. Under certain conditions, a salinity front exists as an offshore boundary of the river plume. This results are compared with observations for the Charngjiang River (in China), and the Chesapeake Bay and Savannah River (in US) estuaries.

SECTION VII. SURVEYS AND INSTRUMENTS

Methods and techniques of field surveys, observation sampling, measurements, and data collection, and various types of instruments, gages, and sampling devices.

Aamodt, T., and Dahl, R. 1984. Modelling of tidal rivers. (See complete entry in Section VI.)

Ashley, G. M., and Grizzle, R. E. 1988. Interactions between hydrodynamics, benthos and sedimentation in a tide-dominated coastal lagoon. (See complete entry in Section II.)

Ashley, G. M., and Zeff, M. L. 1988. Tidal channel classification for a low-mesotidal salt marsh. (See complete entry in Section II.)

Baker, T. F., Edge, R. J., and Jeffries, G. 1982. High precision tidal gravity; Final report, 1 April 1980-31 March 1982. AFGL-TR-82-0163. Hanscom Air Force Base, MA: Air Force Geophysics Laboratory, Air Force Systems Command.

The progress made during the second year of the program is described. The three gravimeter conversions and systems construction are nearly complete. A 6-month tidal gravity experiment was undertaken using ET10, and preliminary results from this experiment are described. Calculations of Indian Ocean tidal loading at various sites around the ocean have been made, and from these results, together with a visit to India and Pakistan, initial sites for the primary observation program have been selected. In addition, a tidal prediction software package is described which will have a wide range of applications in geodynamics measurements which require tidal corrections accurate to ± 0.5 cm or ± 1 microgal. (9 refs)

Bartlett, D. S. 1982. Remote sensing of tidal wetlands: Mapping and beyond. In *Oceans '82 conference record: Industry, government, education... Partners in progress,* 20-22 September 1982, Washington, DC, 458-463. Piscataway, NJ: The Institute of Electrical and Electronics Engineers, Inc.

Remote sensing, primarily using aerial photographs, is a widely established and accepted method in mapping and inventory of tidal wetlands. Wetland habitats are recognized and the boundaries with non-wetlands are drawn primarily on the basis of interpreted vegetative cover as well as on identification of open water, beach, rocky shores, etc. Mapping by remote detection enjoys considerable advantages in speed, flexibility, and cost per area mapped over conventional techniques. With mapping and inventory applications well established, research is focusing more and more on effective sensing of functional processes within the wetlands environment. The accurate measurement of radiometric characteristics made possible by hand-held field radiometers and by aerial and orbital multispectral scanners has produced increased efforts in quantitatively relating remote measurements to environmental parameters. Because of the expense of field measurement of functional variables, use of remote sensing technology, particularly orbital sensors, would be extremely cost-effective relative to conventional methods in these applications. (31 refs)

Bernard, P. C., Van Grieken, R. E., and Eisma, D. 1986. Characterization of the individual suspension particles in the Ems Estuary. (See complete entry in Section VIII.)

Biggs, R. B., and Howell, B. A. 1984. The estuary as a sediment trap: Alternate approaches to estimating its filtering efficiency. (See complete entry in Section II.)

†**Bishop, J. R.** 1984. Wave force investigations at the second Christ-Church Bay tower, summary report, 1982. (See complete entry in Section VIII.)

†**Blaha, G.** 1984. First- and second-phase gravity field solutions based on satellite altimetry. Dania, Florida: Oceanographic Center, Nova University.

The increasing accuracy of satellite altimetry and its growing use in the determination of the general circulation of the oceans provide the motivation for conceiving the most rigorous model possible in relating the pressure and geopotential gradients. In response to such a need, the standard derivation is refined through the inclusion of second-order effects. This refinement is carried out with extensive use of tensor notations. Since altimeter measurements are directly affected by the surface (geocentric) tide, an exact representation of the latter is important. An improvement of the altimeter model with tidal effects included is achieved by an adaptation of Schwiderski's formula giving the ocean bottom deformation due to ocean tidal loading. The resulting model for the bottom tide and, especially, for the surface tide can be used in conjunction with all of the tidal constituents. The point-mass adjustment model, based on the residuals from the spherical-harmonic adjustment of satellite altimetry, was recently modified to allow for an efficient, large-scale resolution of the geoidal detail. As an alternative to the point-mass adjustment (without tidal parameters), an approach is presented which is an adaptation of the collocation theory.

Böhm, E., Magazzu, G., Wald, L., Zoccolotti, M.-L. 1987. Coastal currents on the Sicilian Shelf south of Messina. (See complete entry in Section I.)

Bratkovich, A. 1985. Aspects of the tidal variability observed on the southern California continental shelf. (See complete entry in Section I.)

Broche, P., Salomon, J. C., Demaistre, J. S., and Devenon, J. L. 1986. Tidal currents in Baie de Seine: Comparison of numerical modelling and high-frequency radar measurements. (See complete entry in Section VI.)

Brown, R. D. 1982. Ocean tide measurement by Seasat altimeter data. (See complete entry in Section VIII.)

Butler, R. A., Covington, A. K., and Whitfield, M. 1985. The determination of pH in estuarine waters; II: Practical considerations. (See complete entry in Section VI.)

Catewicz, Z. 1985. On the variability of currents in the coastal zone of the African shelf at 16° North. (See complete entry in Section I.)

Collins, M. B., and Ferentinos, G. 1984. Residual circulation in the Bristol Channel, as suggested by Woodhead sea-bed drifter recovery patterns. (See complete entry in Section I.)

Crickmore, M. J. 1982. Data collection -- Tides, tidal currents and suspended sediment. *Dock & Harbour Authority* 63(742):183-186.

The Hydraulics Research Station, Ltd., has carried out a substantial program of field data collection on behalf of the Severn Barrage Committee to support various hydraulic investigations for the prefeasibility study. Several exercises were mounted to measure tidal levels, currents, salinity, and suspended settlement concentrations. This article describes these operations and is based on a paper presented by the author to the 1981 Severn Barrage Symposium.

Delft Hydraulics Laboratory. 1986. Special issue on estuaries and coastal seas. (See complete entry in Section VI.)

De Resseguier, A. 1983. A portable coring device for use in the intertidal environment. *Marine Geology* 52(1/2):M19-M23.

The construction of a portable coring unit with a telescopic tube and stationary piston mounted on a tripod frame is described. Using the procedure outlined it is possible to core unconsolidated sediments (clay and sands) in intertidal environments with the minimum of disturbance, down to depths of 6 m. (3 refs)

Doerffer, R. 1985. Observations of the suspended matter distribution dynamics in the Elbe Estuary from time series aerial photographs. (See complete entry in Section VIII.)

Donegan, M. E., and White, B. F. 1984. PHAG -- A micro-processor based tide gauge. In *Oceans '84 conference record: Industry, government, education...Designs for the future,* 10-12 September 1984, Washington, DC, 1:254-258. Piscataway, NJ: The Institute of Electrical and Electronics Engineers, Inc.

The design of a low-power portable hydrographic water level gauge system (PHAG) is constrained by environmental, operational, and measurement requirements. The data acquisition electronics provide optimum use of available poer at temperatures ranging below 0°C. The hardware and software provide half-duplex RF telemetry and data transfer for solid-state cartridge or audio mag-tape. The water level measurement includes an analogue pressure sensor or digital absolute encoder driven by a float. A major feature of the design is the power saving by program control of operation time of all electronics and external circuits. Using these criteria including availability, the CMOS 6502 microprocessor is the best solution for the task. (3 refs)

Dooley, H. D. 1979. Factors influencing water movements in the Firth of Clyde. (See complete entry in Section I.)

Emery, K. O., and Aubrey, D. G. 1986. Relative sea-level changes from tide-gauge recrods of eastern Asia mainland. *Marine Geology* 72(1/2):33-45.

Records from 22 tide gauge stations along the mainland coast of eastern Asia document low-frequency vertical movements of the land perhaps biased by unevaluated changes of sea level. The land is rising (relative to sea level) as much as 5 mm year^{-1} in the areas of massifs and ancient foldbelts and subsiding as much as 9 mm year^{-1} in areas of Cenozoic basins and foldbelts. Although the tide gauge records are sparse, inferences from them are supported by the stratigraphy and structure of the region, and by raised and submerged sea level terraces. Thus, relative changes of sea level are heavily influenced here by tectonic and isostatic as well as eustatic

factors, just as in Japan, Scandinavia, and North America where tide-gauge records are much more abundant. Higher frequency (2- to 25-year periods) sea level fluctuations show broad peaks between 2 and 4 years, and near 10 years. Some of these fluctuations correlate with behavior of the Kuroshio Current, which along with freshwater inflow dominates the hydrography of the eastern Asian continental shelves. Observatiosn of water mass fluctuations are too sparse to identify direct causes of all high-frequency variability. (44 refs)

Fagerburg, T. L. 1989. Winyah Bay, Georgetown, South Carolina, data collection survey report. (See complete entry in Section VIII.)

Forrester, W. D. 1986. Direct inference of tidal constituents. *The International Hydrographic Review* 63(2):107-110.

This paper suggests that the traditional methods for adjusting the results of a tidal analysis to allow for the effects of inferred constituents not included in the initial analysis are relics from the days of laborious manual computation. It proposes that the assumed relationships between inferred and reference constituents be incorporated into the initial analysis as conditions on the set of normal equations used in the leastsquares solution. Conceptual and practical advantages of the proposed method are discussed. (3 refs)

Franco, A. S. 1985. Tidal prediction with a small personal computer. *The International Hydrographic Review* 62(2):167-172.

This paper shows how a personal computer with only 16 Kb can be used to work out the prediction of tides with a large number of constituents. In addition, such constituents can be chosen at one's convenience, and their harmonic and other constants can be recorded in any standard minicassette tape. (2 refs)

†**Gantt, R. G.** 1988. The effect of turbidity on the infrared emissivity and thermal mapping of coastal waters. Ph.D. diss., University of Delaware, Newark, NJ.

Thermal infrared (IR) radiometry from satellite and aircraft platforms provides the ocean scientist with perhaps the best means to image synoptically over wide areas sea surface temperature (SST) distributions, internal waves, fronts, eddies, and upwelling of plankton-rich coastal waters. Image interpretation accuracy suffers from the scarcity of sea truth data that are needed to calibrate the gray level scales to relate the radiometric observations to the actual surface temperatures. Variations in sea surface emissivity have generally been discounted as having a significant influence on these interpretations, even though it is recognized that as little as a 1 percent change in emissivity can result in a 2°C difference in SST. The results of research using several different radiometers with different band passes show that under controlled laboraotr4y conditions, emissivity of Delaware Bay seawater does in fact vary between 0.987 and 0.971 in a predictable way as a function of temperature, salinity, and suspended sediment concentration over a range of 10 mg/l to 100,000 mg/l. Suspensions were prepared from organic and inorganic Delaware Bay sediments which were found to have particle size distributions near 0.2 μm. the comparable fresh (tap) water emissivity function is significantly different in that it is almost completely independent of suspended sediment concentration. Observations also show that where the emissivities of organic and inorganic sediments are distinguishable from one another in seawater, they are essentially identical in fresh (tap) water. By systematically applying known visible and near-IR wavelength remote sensing techniques that are able to resolve values of suspended sediment concentration and salinity of the water column, a scheme is proposed for deriving corrected values of sea surface emissivity using the emissivity models developed in this research. Future studies are needed to (a) explore more closely the effect on sea surface emissivity with changes in salinity for various concentrations of suspended sediments; (b) observe the effects of slicks and the thermal boundary layer on emissivity; and (c) determine the effect of particle size and distribution on emissivity.

Glen, N. C. 1986. The tidal survey of the British Isles. *The International Hydrographic Review* 63(1):153-159.

This article discusses the origins of the survey; methods of analysis; tide gauges used; area of the survey including the east coast of Norfolk, the Thames Estuary, the Isle of Wight, and the Bristol Channel; and the progress, which at the time of this article had reached Morecambe Bay, though certain other areas such as the Salway Firth, the Firth of Clyde, and the Sound of Mull had been surveyed as opportunity offered. The area from Barrow-in-Furness to the Salway Firth was under consideration for 1985, with the possibility of a return to Norfolk and the Wash area for 1986 and proceeding northward up the east coast in subsequent years.

Granboulan, J., Villerot, M., Chaumet-Lagrange, M., Reau, J. P., and Henaff, G. 1989. Recent developments in data collection and processing applied to channel maintenance; The case of the Gironde Estuary. (See complete entry in Section V.)

Griffin, D. A., Middleton, J. H., and Bode, L. 1987. The tidal and longer-period circulation of Capricornia, southern Great Barrier Reef. (See complete entry in Section I.)

Hamon, B. V. 1988. Spurious long-period tides due to tide gauge errors. *The International Hydrographic Review* 65(1):159-161.

A combination of tide height errors and resetting the gauge height to a staff reading at a fixed hour each day can lead to spurious long-period signals in series of hourly tide heights. These signals can be of the same order as the fortnightly tides. The problem is discussed in relation to the tides at Sydney (Australia), where it is believed to be responsible for an anomalous Msf tide of amplitude 0.5 cm. (2 refs)

Healy, T., Black, K., and de Lange, W. P. 1985. Numerical model field requirements for detailed simulation of currents and sediment transport in large tidal-inlet harbours. (See complete entry in Section VI.)

Hearn, C. J. 1985. On the value of the mixing efficiency in the Simpson-Hunter h/u^3 criterion. (See complete entry in Section I.)

Hearn, C. J., Hunter, J. R., Imberger, J., and van Senden, D. 1985. Tidally induced jet in Koombana Bay, Western Australia. (See comlpete entry in Section VI.)

Hensley, J. M., and Briggs, M. J. 1988. Tidal elevations and currents at Ponce de Leon Inlet, Florida. (See complete entry in Section VIII.)

Hillier, G. J., and Miller, K. 1987. A new tidal data acquisition and processing system for the Thames. *The Dock & Harbour Authority* 68(791):33-35.

This article describes one particular application of oceanographic software engineering. The tidal data acquisition and processing system installed at the Port of London Authority (PLA) will provide the facility to maintain tidal records for years to come, while at the facility to maintain tidal records for years to come, while at the same time allowing immediate access to real-time data in a variety of easily interpreted graphical and tabular forms. Tidal data lend themselves particularaly to such an acquisition system, since traditionally vast amounts of data are recorded, plotted, reviewed, and analyzed. A number of other applications within the marine sector exist, however, in such areas as wind, wave, and water current data collection.

Howarth, M. J. 1981. Intercomparison of AMF VACM and Aanderaa current meters moored in fast tidal currents. *Deep-Sea Research* 29A(6):601-607.

Records between 1 and 2 months long have been obtained from two American Machine and Foundry, Inc., vector averaging current meters (AMF VACM) and four Aanderaa RCM4's in a shallow sea with storng rectilinear tidal flows and weak residuals. The tidal currents and the residual currents with a daily time scale as recorded by the two meter types were in good agreement. There was poor agreement for the overall mean currents. (5 refs)

Howe, B. M., and Munk, W. H. 1988. Deep-sea moorings in a tidal current. (See complete entry in Section I.)

Hunkins, K. 1986. Anomalous diurnal tidal currents on the Yermak Plateau. (See complete entry in Section VIII.)

Huizinga, P., and Smith, C. J. 1987. Computation of flow through the Palmiet estuary mouth. (See complete entry in Section VI.)

Hydraulics Research Station. 1981. Severn tidal power. (See complete entry in Section VI.)

Jones, D. G., Miller, J. M., and Roberts, P. D. 1984. The distribution of ^{137}Cs in surface intertidal sediments from the Solway Firth. (See complete entry in Section IV.)

†Josanto, V., and Sarma, R. V. 1985. Coastal circulation off Bombay in relation to waste water disposal. (See complete entry in Section IV.)

†Kershaw, P. J. 1989. An investigation of factors influencing the concentration of trace metals in the bottom sediments of the Forth Estaury. (See complete entry in Section II.)

Kineke, G. C., and Sternberg, R. W. 1989. The effect of particle settling velocity on computer suspended sediment concentration profiles. *Marine Geology* 90(3):159-174.

A field study was performed at a site in San Pablo Bay, California, to evaluate how well suspended sediment distribution equations reproduce observed concentrations. Near-bed measurements of current velocity, suspended sediment concentrations, and fluid and particle characteristics were made. An in situ settling cyclinder was used to determine settling velocity values of aggregated suspended sediments, and photographs from a plankton camera provided size estimates. In situ weighted average settling velocities were generally an order of magnitude greater than a weighted average for Stokes calculations of settling veloicty for the grain size distribution of the reference suspended sediment sample and two orders of magnitude greater than a Stokes settling velocity for the median grain size of suspended sediment. Flocs were commonly $\sim 100\ \mu m$ in diameter, and as large as 450 μm, with settling velocities as high as 0.2 cm sec^{-1}. Calculated suspended sediment concentration profiles (within 25 percent) than using settling velocities calculated from the grain size distribution of suspended sediment samples (within 40-50 percent). (27 refs)

Kineke, G. C., Sternberg, R. W., and Johnson, R. 1989. A new instrument for measuring settling velocities in situ. *Marine Geology* 90(3):149-158.

An in situ settling cylinder for determining particle settling velocities has been deployed during a field experiment in San Pablo Bay, California. The instrument is a spring-loaded cylinder which traps approximately 31 of water and suspended sediment between two end plates. Mounted between the end plates is a vertical array of five miniature nephelometers, positioned 4-20 cm below the top end plate, which continuously monitor (5-Hz sampling rate) suspended sediment concentration at each level as particles settle. The resulting settling curve can be divided into components with characteristic settling velocities and a settling velocity distribution obtained for the suspension. The results are conservative estiamtes of settling velocities for the suspension. In situ estimates of particle settling velocity are higher than Stokes settling velocities calculated for the disaggregated grain size distribution of a suspended sediment sample, indicating that the sediment in suspension is in the form of aggregates. The aggregates have settling velocities as high as those of sand size quartz spheres. (27 refs)

Kjerfve, B., and Medeiros, C. 1989. Current vanes for measuring tidal currents in estuaries. *Estuarine, Coastal and Shelf Science* 28(1):87-93.

Current vanes used as submerged drags are simple, reliable, and inexpensive instruments for measuring instantaneous currents in shallow, tidal estuaries. They are superior to current crosses and well-suited for environmental surveys of esturine current distributions. The vanes have been designed for current measurements in the range 0.1-1.6 m sec^{-1} and have an average standard error of the mean of 0.04-0.06 m sec^{-1}, depending on the choice of current speed range. The drag coefficient for the vane is calculated to vary between 1.39 and 1.48. (7 refs)

Lafuente, J. G., Almazan, J. L., Castillejo, F., Khribeche, A., and Hakimi, A. 1990. Sea level in the strait of Gibraltar: Tides. (See complete entry in Section VIII.)

Lanyon, J. A., Eliot, I. G., and Clarke, D. J. 1982. Observations of shelf waves and bay seiches from tidal and beach groundwater-level records. *Marine Geology* 49(1/2):23-42.

Data relevant to shelf waves and bay seiches, with periods between 60 and 10 min, were obtained both from the open ocean and from beach groundwater wells during an experiment monitoring tidal fluctuation of the beach water table at South Beach, Wollongong, Australia. The amplitudes of the shelf waves varied between 10 and 4 cm in the ocean, and their propagation characteristics in the beach water table were examined by Fourier analysis. Typical amplitudes of the shelf waves in the beach water table were of the order of 3 to 1 cm. Amplitude reduction resulted from filtering processes at the beach face slope. (34 refs)

Leendertse, J. J., Langerak, A., and de Ras, M. A. M. 1981. Two-dimensional tidal models for the Delta Works. (See complete entry in Section VI.)

Leffler, M. W., Smith, E. R., and Mason, C. 1986. 1984 nearshore surveys and sediment sampling Assateague Island, Maryland. (See complete entry in Section VIII.)

McCoy, S. E., Long, E. E., and Dingle, G. 1984. Analysis of current meter data collected at Chesapeake Bay entrance from 1981 to 1983. (See complete entry in Section I.)

†McMillan, D. J., and Lynn, N. M. 1983. Fieldwork report: Medway Estaury, 28 June-18 July, 1983. (See complete entry in Section VIII.)

Maas, L. R. M., and van Haren, J. J. M. 1987. Observations on the vertical structure of tidal and inertial currents in the central North Sea. (See complete entry in Section VIII.)

Marsden, R. F. 1986. The internal tide on Georges Bank. (See complete entry in Section VIII.)

Mays, J. 1987. Thorough and versatile tide prediction by computer. *Sea Technology* 28(5):33-37.

This article discusses how the historically sound harmonic method for tide prediction moves from mechanical machines to microcomputers in the form of US tides.

Nadeau, J. E., and Hall, M. J. 1988. Distribution patterns of metals in sediments of the Great Sound Complex, New Jersey. (See complete entry in Section II.)

Oey, L.-Y., Mellor, G. L., and Hires, R. I. 1985. A three-dimensional simulation of the Hudson-Raritan Estuary; Part II: Comparison with observation. (See complete entry in Section VI.)

Osonphasop, C., and Hinwood, J. B. 1984. On measurement of turbulence and shear stresses in tidal currents. (See complete entry in Section VIII.)

Outlaw, D. G., and Butler, H. L. 1982. Model verification using tidal constituents. (See complete entry in Section VI.)

†**Peshwe, V. B., Diwan, S. G., Joseph, A., and Desa, E.** 1982. Wave and tide gauge. *Indian Journal of Marine Science* 9:73-76.

A wave and tide gauge has been developed utilizing a strain gauge pressure transducer. The transducer with associated electronic circuitry gives an output voltage proportional to the water column above it. The instrument has been field tested as a tide gauge in shallow waters where there is minimal wave activity and also as a wave recorder. In both cases appropriate filtering is applied to emphasize the measuring parameter. The unit may also be used as a wave recorder in deep waters with appropriate corrections. Possible improvements in the mechanical fabrication and the electronic circuitry are discussed.

Pickard, G. L. 1986. Effects of wind and tide on upper-layer currents at Davies Reef, Great Barrier Reef, during MECOR (July-August 1984). (See complete entry in Section I.)

Ports, M. A., ed. 1989. *Hydraulic Engineering*. (See complete entry in Section I.)

Pradle, D. 1987. The fine-structure of nearshore tidal and residual circulations revealed by H. F. radar surface current measurements. (See complete entry in Section I.)

Pritchard, D. W., and Vieira, M. E. C. 1984. Vertical variations in residual current response to meteorological forcing in the mid-Chesapeake Bay. (See complete entry in section VIII.)

Puls, W., and Kuehl, H. 1986. Field measurements of the settling velocities of estuarine flocs. (See complete entry in Section VIII.)

Salomão, J. M. 1987. A survey for salinity intrusion and pollution assessment in Maputo estuary. *Water Science and Technology* 19(5/6):823-832.

Following surveys recently carried out in Maputo Estuary, a sruvey with the purpose of acquiring data required to characterize the estuary was carried out in December 1983. After reviewing the hydrology of the tributaries to the estuary, the parameters to be monitored, salinity, conductivity, temperature, and dissolved oxygen, are referred. Finally, taking also into account previous information available, an evaluation of the results and an assessment of the estuary are done. The estuary can be classified as well mixed, since the vertical salinity gradients found are small. The Umbeluzi Estuary, however, is partially mixed. Temperature decreases with the depth and when moving downstream. Some pollution was found along the lower part of the estuary, probably due to the discharge of domestic and industrial wastewater, which brings the dissolved oxygen figures below the saturation level. As for the upper part of the estuary, the dissolved oxygen levels are not only dependent on the pollutant load, but also on the growing of algae, which by photosynthesis under daylight produces oxygen that dissolves into the water. Quite often, the dissolved oxygen figures are above the saturation level. The growth of algae could be due to the input of phosphorus and nitrogen brought in by the tributary streams. A pollutant load discharged upstream could be the reason for some pollution seen in the Umbeluzi Estuary. (19 refs)

Satake, K., Okada, M., and Abe, Kuniaki. 1988. Tide gauge response to tsunamis: Measurements at 40 tide gauge stations in Japan. (See complete entry in Section VIII.)

Schroeder, W. W., Huh, O. K., Rouse, L. J. Jr., and Wiseman, W. J., Jr. 1985. Satellite observations of the circulation east of the Mississippi Delta: Cold-air outbreak conditions. (See complete entry in Section I.)

Sherwin, T. J. 1988. Analysis of an internal tide observed on the Malin Shelf, north of Ireland. (See complete entry in Section I.)

Smith, P. E., ed. 1982. *Proceedings of the conference applying research to hydraulic practice.* (See complete entry in Section I.)

†**Staples, D. J.** 1983. Environmental monitoring: climate of Karumba and hydrology of the Norman River Estuary, southeast Gulf of Carpentaria. Report No. CSIRO 156. Cronulla, New South Wales, Australia: CSIRO Marine Laboratory.

An automatic event recorder was used to monitor six climatic variables (air temperature, relative humidity, wind speed and direction, barometric pressure, rainfall) and five hydrological variables (conductivity (salinity), water temperature, tide height, current speed and direction) at Karumba in northern Queensland and the adjacent Norman River Estuary, monitorihng was carried out from December 1976 until August 1979. The data set was analyzed at three different time scales ranging from hourly values, which were used to examine diel and tidal variation of parameters from a subset of the data, to monthly means, which were used to determine seasonality and year-to-year variation. Much of the small time scale variation could be accounted for by diel cycles in the case of climatic variables and tidal cycles for hydrological variables. Although Karumba lies well within the tropical equatorial zone, all variables showed marked seasonality. Winter was characterized by higher barometric pressures, cool southeast to east trade winds, and virtually no rain. In summer, as the low-ressure equatorial air masses moved south, northeasterly to northwesterly monsoonal winds predominated, and a rainfall ranging from 441-1,184 mm fell between December and March each year. Year-to-year differences in climate and associated physical and chemical environment are discussed.

Sternberg, R. W. 1979. Bottom-current measurements and circulation in Western Port, Victoria. (See complete entry in Section VIII.)

Sternberg, R. W., Caccione, D. A., Drake, D. E., and Kranck, K. 1986. Suspended sediment transport in an estuarine tidal channel within San Francisco Bay, California. (See complete entry in Section II.)

Tait, B. J., Grant, S. T., St.-Jacques, D., and Stephenson, F. 1986. Canadian Arctic tide measurement techniques and results. *The International Hydrographic Review* 63(2):111-131.

About 10 years ago the Canadian Hydrographic Service recognized the need for a planned approach to completing tide and current surveys of the Canadian Arctic Archipelago in order to meet the requirements of marine shipping and construction industries as well as the needs of environmental studies related to resource development. Therefore, a program of tidal surveys was begun which has resulted in a database of tidal records covering most of the Archipelago. In this paper the problems faced by tidal surveyors and others working in the harsh Arctic environment are described and the variety of equipment and techniques developed for short-, medium-, and long-term deployments are reported. The tidal characteristics throughout the Archipelago, determined primarily from these surveys, are briefly summarized. It was also recognized that there would be a need for real-time tidal data by engineers, surveyors, and mariners. Since the existing permanent tide gauges in the Arctic do not have this capability, a project was started in the early 1980's to develop and construct a new permanent gauging system. The first of these gauges was constructed during the summer of 1985 and is described. (28 refs)

ten Brummelhuis, P. G. J., de Jong, B., and Heemink, A. W. 1988. Stochastic dynamic approach to predict water levels in estuaries. (See complete entry in Section VI.)

Thomson, J. D., and Godrey, J. S. 1985. Circulation dynamics in the Derwent Estuary. (See complete entry in Section III.)

Usachev, I. N., and Bernshtein, L. B. 1988. Investigations at the Kislogubsk Tidal Power Station. (See complete entry in Section VIII.)

Walton, R. Kossik, R. Adams, E., and Cosler, D. 1989. Far-field numerical model studies for Boston's new secondary treatment plant outfall siting. (See complete entry in Section IV.)

Wang, J. D., and van de Kreeke, J. 1986. Tidal circulation in North Biscayne Bay. (See complete entry in Section VI.)

Wang, S. Y., Shen, H. W., and Ding, L. Z. 1986. *River Sedimentation.* (See complete entry in Section II.)

Weishar, L. L., and Aubrey, D. G. 1988. Inlet hydraulics at Green Harbor, MJarshfield, Massachusetts. (See complete entry in Section V.)

West, J. R., Knight, D. W., and Shiono, K. 1986. Turbulence measurements in the Great Ouse Estuary. *Journal of Hydraulic Engineering,* ASCE, 112(3):167-180.

Field measurements have been made of the turbulent fluctuations of the longitudinal and vertical components of velocity by using an electromagnetic flowmeter in a partially mixed reach of the Great Ouse Estuary. An error analysis of the results showed that the measurement technique was satisfactory for determining most turbulence parameters. The effects of stratification were clearly apparent in the length scales, energy spectra, and cospectra of the turbulent fluctuations. The characteristics of the turbulence were found to be similar to those for laboratory flume data and stably stratified atmospheric boundary layer data for various specific conditions. More data are required to cover a wider range of conditions. (32 refs)

West, J. R., and Oduyemi, K. O. K. 1989. Turbulent measurements of suspended solids concentration in estuaries. *Journal of Hydraulic Engineering*, ASCE, 115(4):457-474.

Measurements of turbulent fluctuations of horizontal and vertical components of velocity and of suspended solids concentration in the region of 0.50 to 1.25 m above the bed have been made in the upper reaches of the Conwy and Tamar Estuaries. The characteristics of the turbulence for the velocity components were found to be similar to those for laboratory flume data for appropriate steady and homogeneous conditions. The characteristics of the turbulence fluctuations of suspended solids concentration were found to be in some ways similar to those of the turbulent fluctuations of the horizontal and vertical components of velocity and salinity. The relative velocities are strongly dependent on relative depth and particle radient Richardson number. The intensity of the suspended solids concentration fluctuations increases with the suspended solids concentration vertical gradient. The momentum and suspended solids flux correlation coefficients descrease with increasing gradient Richardson number, with the vertical suspended solids flux correlation coefficient decreasing more rapidly than the horizontal suspended solids flux correlation coefficient. These effects are tentatively explained by the concept of turbulent fluctuations being progressively replaced by wave-like fluctuations in stable conditions. (19 refs)

Zeff, M. L. 1988. Sedimentation in a salt marsh-tidal channel system, Southern New Jersey. (See complete entry in Section II.)

Zetler, B. D. 1987. The evolution of modern tide analysis and prediction - Some personal memories. *The International Hydrographic Review* 64(1):122-139.

The science of tide analysis and prediction reached so high a level of achievement in the early years of this century that there was little change or improvement for about 50 years. However, as electronic computers became both available and more powerful, very significant changes were introduced into virtually all aspects of tide observation, analysis, and prediction. By virtue of this author's service for many years in the US Coast and Geodetic Survey, the Atlantic Meteorological and Oceanographic Laboratories and, more recently, at Scripps Institution of Oceanography, he has been a participant in many aspects of the changed procedures. His memories of how these changes came about are featured in this paper. (46 refs)

SECTION VIII. BASIC PHYSICAL DATA

Tide tables, datum planes, tidal current charts, and the results, tabulation, and discussion of basic physical data obtained from field surveys, investigations, and data collection programs. Physical features of ports, harbors, estuaries, etc., when related to tidal hydraulic problems.

Aamodt, T., and Dahl, R. 1984. Modelling of tidal rivers. (See complete entry in Section VI.)

†**Agnew, D. C.** 1984. Sea level variations and ocean dynamics in the Aleutian Islands. (See complete entry in Section I.)

Allen, J. R. L. 1987. Coal dust in the Severn Estuary, southwestern UK. (See complete entry in Section IV.)

Allen, J. R. L., and Rae, J. E. 1988. Vertical saltmarsh accretion since the Roman period in the Severn Estuary, Southwest Britain. *Marine Geology* 83(1/4):225-235.

Using three methods of measurement, and averaging over the whole estuary, the vertical sediment accretion on mature clastic salt marshes amounts to 1.22 m since the Roman period (ca. A.D. 150), 1.05 m since the Medieval Period (ca. A.D. 1250), 0.54 m since ca. A.D. 1845, and 0.21 m since ca. A.D. 1945. These data are cautiously interpreted to mean that the trend of relative sea level in the Severn Estaury is continuing upward (shroter term negative tendencies are not excluded), and that the current rate of rise could be a few millimeters per year. The measured sediment thicknesses cannot be equated directly with relative movements of sea level, however, because of effects related mainly to (a) changes in the tidal range with general deepening, (b) the possible transgression up the Severn Vale of the estuary as a whole, and (c) the possible raising of tidal levels due to wetland reclamation. After estimating for all these factors, the true relative rise since the Roman Period could have amounted to 1.6-1.7 m. (72 refs)

Amano, K., and Fukushima, T. 1988. On the longitudinal and vertical changes in lake estuarine sediments. (See complete entry in Section IV.)

Anderson, F. E., and Meyer, L. M. 1986. The interaction of tidal currents on a disturbed intertidal bottom with a resulting change in particulate matter quantity, texture and food quality. (See complete entry in Section II.)

Anderson, G. F. 1986. Silica, diatoms and a freshwater productivity maximum in Atlantic coastal plain estuaries, Chesapeake Bay. (See complete entry in Section III.)

Andrews, J. C., Dunlap, W. C., and Bellamy, N. F. 1984. Stratification in a small lagoon in the Great Barrier Reef. (See complete entry in Section III.)

Ashley, G. M., and Grizzle, R. E. 1988. Interactions between hydrodynamics, benthos and sedimentation in a tide-dominated coastal lagoon. (See complete entry in Section II.)

Ashley, G. M., and Zeff, M. L. 1988. Tidal channel classification for alow-mesotidal salt marsh. (See complete enty in Section II.)

Baker, E. T. 1984. Patterns of suspended particle distribution and transport in a large fjordlike estuary. (See complete entry in Section I.)

Baker, T. F., Edge, R. J., and Jeffries, G. 1982. High precision tidal gravity; Final report, 1 April 1980-31 March 1982. (See complete entry in Section VII.)

Bale, A. J., Morris, A. W., and Howland, R. J. M. 1985. Seasonal sediment movement in the Tamar Estuary. (See complete entry in Section II.)

†**Bales, J. D.** 1986. Field and numerical studies of tracer gas transport and surface gas transfer in laterally uniform, partially stratified estuaries. (See complete entry in Section VI.)

Bales, J. D. 1989. Land drainage and estuarine salinity response. (See complete entry in Section III.)

Bales, J. D., and Holley, E. R. 1989. Sand transport in Texas tidal inlet. (See complete entry in Section II.)

†**Balls, M.** 1988. The optimal selection of turbine-generators for tidal power projects and the optimization of their operation. (See complete entry in Section VI.)

Barthe, X., and Castaing, P. 1989. Theoretical study of the action of tidal currents and swell on the sediments of the continental shelf of the Bay of Biscay (Étude théorique de l'action des courants de marée et des houles sur les sédiments du plateau continental de Golfe de Gascogne). (See complete entry in Section II.)

Barwell, L. 1988. Dynamics of the Palmiet River mouth. (See complete entry in Section I.)

Bassoullet, P., Djuwansah, R., Gouleau, D., and Marius, C. 1986. Hydrosedimentological processes and soils of the Bariot Estuary (South Kalimantan, Indonesia). (See complete entry in Section II.)

Beasley, E. L., Hiller, M. A., and Biggs, R. B. 1988. Susceptibility of U.S. estuaries to pollution. *Water Science and Technology* 20(6/7):211-219.

Utilizing data primarily from the U.S. Department of Commerce, both estuaries and watersheds for 78 U.S. systems are analyzed. Watersheds are classified according to total population and discrete subpopulations. The Vollenweider approach, which compares hydraulic loading to nutrient loading of lakes, is adapted to estuaries. By considering total population as a surrogate of point source nutrients, agricultureal workers as a surrogate of nonpoint source toxics and nutrients and chemical + metal workers as a surrogate of point source toxics, we can estimate potential anthropogenic impacts on watersheds. When these surrogates are plotted against hydraulic loading, managers have a tool to identify estuaries most likely to be under greatest anthropogenic pressure. The estuaries with highest susceptibility from total population, as well as the estuaries with the highest susceptibility to toxic stress, are identified. On a Vollenweider diagram, the phosphorous loadings of freshwater bodies are plotted as a function of hydraulic loading. The permissible-excessive phosphorous loadings have been both theoretically and empirically determined. We have replotted the freshwater data and added 33 U.S. estuary P loadings that were previously unavailable. Estuaries plot on the Vollenweider diagram as a continuum of freshwater bodies, both in terms of hydraulic loading and phosphorus loading. Most estuaries appear to have permissible P loadings. Analysis of nutrieint loading (normalized to hydraulic loading) versus water quality parameters like chlorophyll *a* indicates that estuaries are more efficient users of nutrients than are freshwater bodies, and that they reach a "nutrient saturation point." Perhaps this is due to grazing or turbidity. It appears that, in general, the OECD eutrophication modeling approach is applicable to estuarine systems as well as lakes and impoundments. (12 refs)

Bedford, K. W. 1985. Selection of turbulence and mixing parameterizations for estuary water quality models. (See complete entry in Section VI.)

Berger, P., Laane, R. W. P. M., Llahude, A. G., Ewald, M., and Courtot, P. 1984. Comparative study of dissolved fluorescent matter in four West-European estuaries. (See complete entry in Section IV.)

Berger, R. C., Jr., Heltzel, S. B., Athow, R. F., Jr., Richards, D. R., and Trawle, M. J. 1985. Norfolk Harbor and channels deepening study; Report 2, Sedimentation investigation; Chesapeake Bay hydraulic model investigation. (See complete entry in Section II.)

Bernard, P. C., Van Grieken, R. E., and Eisma, D. 1986. Characterization of the individual suspension particles in the Ems Estuary. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:488-496. University, MS: University of Mississippi.

Samples of suspended matter were taken in the Ems Estuary during high and low run-off discharge, in November-December 1982 and May 1984, respectively. Small aliquots of water were filtered over a Nuclepore membrance. These filters were automatically analyzed on the particle-by-particle basis for the elements and for particle size. For each of the 24 samples, approaximately 300 particles were measured for their chemical composition and morphology. The interpretation of this large amount of information is made possible by the classification of the particles into various particle types on the basis of their chemical composition using numerical multivariate analysis. For high and low runoff conditions in the Ems Estuary, this procedure provided 13 and 11 geochemically different particle types, respectively, of which the relative abundance could be followed throughout the estuary. This method allows the advanced characterization of the fluvial and marine suspended particulate matter, while the mixing ratios of marine to fluvial material are used to study the transport processes in the Ems Estuary. (7 refs)

Bernstein, L. 1986. Tidal power engineering in the USSR. *Water Power & Dam Construction* 38(3):37-41.

Since construction of the world's first tidal powerplant in the late 1960's (the 400-kW Kislaya Guba pilot scheme) much progress has been made in tidal power engineering in the Soviet Union. Experience with the operation of Kislaya Guba for 17 years has been used as the basis for further research, and three large-scale tidal projects are now planned for construction. The author gives details of the design of these three schemes, and also discusses the role tidal

power could play in supplying peak power to the interconnected grid systems of Western Europe. (10 refs)

Biggs, R. B., and Howell, B. A. 1984. The estuary as a sediment trap: Alternate approaches to estimating its filtering efficiency. (See complete entry in Section II.)

Birch, P. B., Forbes, G. G., and Schofield, N. J. 1986. Monitoring effects of catchment management practices on phosphorus loads into the eutropic Peel-Harvey Estuary, western australia. (See complete entry in Section IV.)

†**Bishop, J. R.** 1984. Wave force investigations at the second Christ-Church Bay tower, Summary report, 1982. Teddington, England: National Maritime Institute.

Fluid loading on offshore structures was investigated using an instrumented tower. Particle kinematics were measured at various depths. Tidal currents were measured to calibrate predictions of current and tide height and to evolve a method of correcting the zero readings of transducers, by reference to the symmetry of velocities and current-induced forces in the tidal cycle. The investigations show that prediction methods such as linear wave theory are reliable.

Biswas, A. N., and Bandyopadhyay, K. K. 1987. Scour at Haldia Oil Jetty on the Hugli Estuary. (See complete entry in Section II.)

Blaauw, H. G., Lindenberg, J., Strating, J., and Vellinga, P. 1983. Numerical models in poort design. (See complete entry in Section VI.)

Bodge, K. R., and Dean, R. G. 1987. Short-term impoundment of longshore sediment transport. (See complete entry in Section II.)

Boersma, J. R., and Terwindt, J. H. J. Neap-spring tide sequences of intertidal shoal deposits in a mesotidal estuary. (See complete entry in Section I.)

†**Bogdanov, K. T., and Kharkov, B. V.** 1975. Calculation of Indian Ocean tides. *Oceanology* 15:156-160 (Translated from Russian).

New tidal charts are presented for the components of the M_2, and S_2, K_1, and 0_1 tidal waves for the waters of the Indian Ocean. The charts were prepared from solutions of the system of hydrodynamic tidal equations (first boundary-value problem). The correctness and accuracy of the tidal charts were verified by precomputation of the actual and calculated values of the harmonic constants of the tide on islands in the Indian Ocean. The principal features of the tidal level variations over the ocean are reported. (9 refs)

Böhm, E., Magazzu, G., Wald, L., Zoccolotti, M.-L. 1987. Coastal currents on the Sicilian Shelf south of Messina. (See complete entry in Section I.)

†**Bollinger, M. S.** 1986. Radium isotopes in salt marsh and estuarine environments. Ph.D. diss., University of South Carolina, Columbia.

Dissolved 226Ra, 228Ra, and 224Ra data from the tidal creeks and interstitial water and radium and thorium data from the sediments of salt marshes in South Carolina, Delaware, and Massachusetts are presented. Dissolved radium activities in the tidal creeks were two to three times higher inthe summer than at any other time because of increased bioturbation rates during the warm months. Radium activities in a tidal creek of the marsh surrounding North Inlet, SC, were three times higher than in the creeks of the Great Marsh, DE, and the Great Sippewissett Marsh, MA, primarily due to higher thorium activities in the southern marsh sediments. Diffusion out of the marsh sediments, drainage of porewater from creek banks near low tide, and bioturbation which brings high radium activity porewater and sediments toward the surface of the marsh and increases the surface area over which diffusion and desorption may occur control the dissolved radium activities in the tidal creeks. In each of the marshes the 224Ra/228Ra and 228Ra/226Ra activity ratios in the tidal creeks (1.7 and 2.7, respectively) and the 230Th/232Th and 228Th/232Th activity ratios in the sediments (1.0 and 0.8, respectively) are similar, despite large geographical and physiological differences among the marshes. The 224Ra/228Ra and 228Ra/226Ra activity ratios in the marsh creeks are apparently controlled by the residuence times of water in the creeks and sediments and by the radium activity ratios supplied by the sediments of the marshes. Radium isotopes enter the marsh system dissolved in coastal ocean water or groundwater or are produced from the decay of thorium in the salt marsh sediments. Radium produced in the sediments may desorb into the interstitial waters of the marsh. Because of these unique source functions, radium isotopes act as useful tracers of water movements within the marsh systems. The distribution of radium in the South Carolina marsh-tidal creek system has been used to determine the residence time

of water in the top centimeters of the sediments to be on the order of hours in the creek bank sediments and 1 to 7 days in the high marsh sediments.

Bose, S. K., Ray, P., and Dutta, B. K. 1988. Water quality management of the Hooghly Estuary--A linear programming model. (See complete entry in Section VI.)

Bottin, R. R., Jr., Outlaw, D. G., and Seabergh, W. C. 1985. Effects of proposed harbor modifications on wave conditions, harbor resonance, and tidal circulation at Fish Harbor, Los Angeles, Califorinia; Physical and numerical model investigations. (See complete entry in Section VI.)

Bowman, M. J., Kibblewhite, A. C., Murtagh, R. A., Chiswell, S. M., and Sanderson, B. G. 1983. Circulation and mixing in Greater Cook Strait, New Zealand. (See complete entry in Section I.)

Broche, P., Salomon, J. C., Demaistre, J. S., and Devenon, J. L. 1986. Tidal currents in Baie de Seine: Comparison of numerical modelling and high-frequency radar measurements. (See complete entry in Section VI.)

Brockmann, C. W., and Dippner, J. W. 1987. Tidal correction of hydrographic measurements. (See complete entry in Section VI.)

Brogdon, N. J., Jr. 1986. Estuary model test evaluation. Miscellaneous Paper Hl-86-7. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Salinity data from physical model studies of nine estuaries and pertinent information on each estuary were analyzed in an effort to develop rapid and effective techniques to evuation the changes in salinity that would occur due to modification (deepening) of navigation channels. Several analysis approaches to the model data were attempted in an effort to achieve the objective of this research unit. At the time of publication, no successful technique had been developed that meets the objective. However, it is recommended that efforts to develop a technique to evaluate the change in salinity due to channel deepening continue. The magnitude of salinity change due to channel modification is dependent to a large degee on each of the phenomena listed in the following tabulation. The results and conclusions presented for each estuary studied in this report could be applied, with engineering judgment, to similar systems to reach a quick and general estimate of salinity change due to channel modification.

Estuary	Salinity Intrusion miles	Maximum Width 10^3 ft	Mean Inflow cfs	Mean Tide Range ft	Tidal Prism ft^3	Channel Depth Change ft
Grays Harbor	23	66	10,000	9.0	1.7×10^{10}	10
Tillamook Bay	13	13	28,000	5.7	1.64×10^{9}	22
Matagorda Bay	40	155	800	0.7	8.7×10^{9}	29
Mobile Bay	52	123	61,000	1.3	3.4×10^{10}	10
Savannah River	20	3	8,500	6.9	3.1×10^{9}	6
Charleston Harbor	26	15	15,600	5.2	5.8×10^{9}	5
Georgetown Harbor	19	21	10,000	4.6	3.0×10^{9}	8
James River	65	30	7,350	2.6	8.7×10^{9}	10
Chesapeake Bay	215	156	72,400	2.8	13.9×10^{10}	8

Brogdon, N. J., Jr., and White, D. M. 1985. Newburyport Harbor, Massachusetts; Report 2, Design for hydrodynamics, salinity, and sedimentations; Hydraulic model investigation. (See complete entry in Section VI.)

Brown, R. D. 1982. Ocean tide measurement by Seasat altimeter data. In *Ocean '82 conference record: Industry, government, education...Partners in progress,* 20-22 September 1982, Washington, DC, 439-444. Piscataway, NJ: The Institute of Electrical and Electronics Engineers, Inc.

Tides in the deep ocean have been measured directly by satellite altimetry, independent of knowledge of earth tides, ocean loading, tidal dissipation, or ocean bottom topography. Conventional tide preditions for the deep ocean are sensitive to uncertainties in these parameters. Correction of Seasat altimetry for orbit uncertainty, and subsequent harmonic analysis of subtrack crossover differences, provide a simple and direct measure of the ocean tide. Comparison of M2 altimetric tide parameters at 11 locations in the northeast Pacific with those determined from bottom pressure gauges shows fair agreement at five locations, but puzzling systematic differences at the other locations. The estimated precision of the altimeter solutions is 8 cm in amplitude and 10 deg in phase angle. (13 refs)

Brown, W. D., and Trask, R. P. 1980. A study of tidal dissipation and bottom stress in an estuary. (See complete entry in Section I.)

†**Bukatov, A. Y., et al.** 1978. Tidal-period internal waves in the equatorial zone of the Indian Ocean. (See complete entry in Section VI.)

Burton, J. H., and Healy, T. R. 1985. Tidal hydraulics and stability of the Maketu Inlet, Bay of Plenty. (See complete entry in Section II.)

Butler, H. L. 1982. Numerical modeling of inlet-estuary system. (See complete entry in Section VI.)

Butler, H. L., and Sheng, Y. P. 1982. ADI procedures for solving the shallow-water equations in transformed coordinates. (See complete entry in Section VI.)

Butler, R. A., Covington, A. K., and Whitfield, M. 1985. The determination of pH in estuarine waters; II: Practical considerations. (See complete entry in Section VI.)

Caillat, J.-M. 1983. Effect of salinity on deposit distribution in estuarian channels. (See complete entry in Section III.)

Cameron, I., and Ho, G. E. 1985. Disposal of wool scouring effluent in an estuarine environment. (See complete entry in Section IV.)

Carson, B., Ashley, G. M., Lennon, G. P., Weisman, R. N., Nadeau, J. E., Hall, M. J., Faas, R. W., Zeff, M. L., Grizzle, R. E., Schuepfer, F. E., Young, C. L., Meglis, A. J., Carney, K. F., and Gabriel, R. 1988. Hydrodynamics and sedimentation in a back-barrier lagoon-salt marsh system, Great Sound, New Jersey -- A summary. (See complete entry in Section II.)

Carson, B., Carney K. F., and Meglis, A. J. 1988. Sediment aggregation in a salt-marsh complex, Great Sound, New Jersey. (See complete entry in Section II.)

Cartwright, D. E. 1985. Tidal prediction and modern time scales. (See complete entry in Section I.)

Cartwright, D. E., and Amin, M. 1986. The variances of tidal harmonics. *Deutsche Hydrographische Zeitschrift* 39(6):235-253.

The variances, or squared standard errors, of estimates of tidal harmonic constants from analyses of a month or a year of tide gauge data are analyzed in terms of spectral properties of their noise continuum, modelled as exponential cusps E_1 superimposed on a smoothly monotonic nontidal spectrum E_0 is evaluated from the inter-species noise levels, and E_1 from the ratio of the variances from monthly and yearly analyses. It is shown that the cusps surrounding the diurnal tides are dominated by E_0, whereas the more important semi-dirunal and higher species cusps are fitted by an exponential form for E_1 with bandwidth of a few cycles per year. The variance ratios (monthly: yearly analyses) for diurnal harmonics are somewhat greater than the value expected for white noise, partly becaue of residual tidal lines in the monthly analyses which cannot be related to the major constituents. The corresponding ratios for semi-diurnal and higher spacies harmonics are less than the white noise value, on account of the cusps. The standard errors of yearly estimates of the larger tidal constituents may be predicted as proportional to their mean amplitude, as a very rough guide, in the approximate ratio of 11 mm/m. (9 refs)

Castillo, F. P. 1983. Historical coastline changes at the southern shore of the Gulf of Venezuela. (See complete entry in Section V.)

Catewicz, Z. 1985. On the variability of currents in the coastal zone of the African shelf as 16° North. (See complete entry in Section I.)

Central Board of Irrigation and Power. 1988. Tidal power development. (See complete entry in Section VI.)

†**Chabert D'Hieres, G., and Le Provost, C.** 1978. Atlas of tidal constituents in the Channel (Atlas des composantes harmoniques de la maree dans la manche). *Annales Hydrographiques* 6(3):1-32 (In French).

This atlas presents 26 groups of charts giving the distribution of amplitudes and phases of the principal harmonic constituents of the tides all over the English channel. These nets have been established from observed data in some ports along the coasts, with the help of a hydraulic reduced model of that sea, built upon a rotating platform. (7 refs)

†**Chaoyu, W.** 1986. A dynamics and sedimentology study of eastern Atchafalaya Bay, Louisiana. (See complete entry in Section II.)

Chen, C. L. 1988. Analytic solutions for tidal model testing. (See complete entry in Section VI.)

†**Cheng, R. T., and Walters, R. A.** 1982. Modelling of estuarine hydrodynamics and field data requirements. (See complete entry in Section VI.)

Childers, D. L., and Day, J. W., Jr. 1988. A

flow-thorugh flume technique for quantifying nutrient and material fluxes in microtidal estuaries. *Estuarine, Coastal and Shelf Science* 27(5):483-494.

The marsh flume methodology has been modified for use in northern Gulf Coast estuaries, where tidal ranges are small and irregular and where wetlands are flat and expansive. In this technique, two key changes have been made: (a) flumes are open to water exchange at both ends, and (b) samples are taken simultaneously at both ends throughout a tidal cycle. Thus, the flumes are conceptually through-flow systems. Nutrients fluxes are calculated volumetricaly, from the microtopography of the marsh and changes in water height over a tidal cycle. Instantaneous fluxes across each end of the flume are pooled for flooding or ebbing flow, then subtracted to give total net flux. Data from three flumes built in fresh, brackish, and saline marshes of the Barataria Basin Estuary, Louisiana, show that significant concentration differences (and hence significant fluxes) are detectable using this modified flume technique. Net areal flux values measured using the modified technique are in close agreement with values reported from past studies using flumes where concentrations are sampled only at the mouth end. The similarities indicate that these modifications to the flume methodology allowed the authors to quantify adequately the nutrient and material fluxes between Gulf Coast marshes and their inundating water column. This technique has applications in any estuary where marshes are microtidal, expansive, or irregularly flooded. (39 refs)

Christian, R. B., Stanley, D. W., and Daniel, D. A. 1984. Microbiological changes occurring at the freshwater-seawater interface of the Neuse River Estuary, North Carolina. (See complete entry in Section III.)

Christiansen, C., Christoffersen, H., and Lomholt, S. 1981. Characteristics of three-layer circulation and inverse surface salinity gradients in two small semi-enclosed Danish embayments. (See complete entry in Section III.)

†Chrzastowski, M. J. 1986. Stratigraphy and geologic history of a Holocene lagoon: Rehoboth Bay and Indian River Bay, Delaware. (See complete entry in Section II.)

Chu, W.-S., Barker, B. L., and Akbar, A. M. 1988. Modeling tidal transport in the Arabia Gulf. (See complete entry in Section VI.)

Chu, W.-S., and Yeh, W. W.-G. 1985. Calibration of a two-dimensional hydrodynamics model. (See complete entry in Section VI.)

Chu, Y.-H., and Chen, H. S. 1985. Bechevin Bay, Alaska, inlet stability study. (See complete entry in Section VI.)

†Chuang, W.-S., and Swenson, E. M. 1981. Subtidal water level variations in Lake Pontchartrain, Louisiana. *Journal of Geophysical Research* 86(C5):4198-4204.

Lake Pontchartrain, Louisiana, has two major tidal passes connecting it to the Mississippi Sound and thence to the Gulf of Mexico. The subtidal variability in this system and its relation to wind forcing over a 7-month period were examined. The coherence of water level fluctuations in the lake and passes with those of th esound was high at all time scales, and the water level in all data sets responded to the east-west wind at time scales shorter than 15 days. Since the local coastline is approximately in the east-west direction, the results suggest a coupled coastal ocean-lake response. A linear fraction model was developed, and it accounted for most of the observed features.

Church, J. A., and Forbes, A. M. G. 1983. Circulation in the Gulf of Carpentaria: I. Direct observations of currents in the south-east corner of the Gulf of Carpentaria. (See complete entry in Section I.)

†Churchill, J. H. 1984. Analysis of flow within the coastal boundary layer off Long Island, New York. Report No. WHOI-84-14. Woods Hole, MA: Woods Hole Oceanographic Institution.

From 1974 through 1978 a series of intensive measurements were made in the coastal waters within 12 km of Long Island. The data were derived from two sources: a mooring array from which time series of temperature, salinity, and water velocity were measured at four depths at each of four offshore distances; and high-resolution, daily hydrographic surveys. Analysis of subtidal cross-shore velocity fluctuations indicated a two-layer response to wind forcing, with near-surface flow to the right of the longshore wind and opposing flow below. The magnitude of these fluctuations increased in the seaward direction on a scale nearly equal to the internal deformation radius. The phase between longshore velocity fluctuations and longshore wind stress approached zero with decreasing bottom depth, probably the result of bottom stress. The vertical

structure of longshore fluctuations during stratified conditions, markedly differed from that during unstratified condtions, and resembled the structure derived from a simple two-layer coastal flow model.

Cialone, M. A. 1986. Yaquina Bay, Oregon, tidal and wave-induced currents near the jettied inlet; Numerical model investigation. (See complete enty in Section VI.)

Cochran, J. K. 1984. The fates of uranium and thorium decay series nuclides in the estuarine environment. (See complete entry in Section II.)

Colman, S. M., Berquist, C. R., Jr., and Hobbs, C. H. III. 1988. Structure, age and origin of the bay-mouth shoal deposits, Chesapeake Bay, Virginia. (See complete entry in Section II.)

Copeland, R. R. 1986. San Lorenzo River sedimentation study; numerical model investigation. (See complete entry in Section VI.)

Corapcioglu, M. Y. 1987. Pressure change and surface expansion in salt marshes due to tidal inundation. (See complete entry in Section II.)

Costa, S. L., Landsteiner, M. C., Stork, J. W., and Gould, T. C. 1982. Discharge-displacement calculations for tidal flushing. In *Oceans '82 conference record: Industry, government, education...Partners in progress,* 20-22 September 1982, Washington, DC, 784-790. Piscataway, NJ: The Institute of Electrical and Electronics Engineers, Inc.

Occasionally it is necessary to determine displacement/discharge estimates of material introduced into coastal lagoons. The use of sophisticated numerical models may be inappropriate due to cost or time constraints. A technique is presented here to provide relatively quick estimates with a minimum amount of data. An example of the scheme applied to a multi-basin inlet-bay system is given for the application of a phased ebb discharge of material. Based on segmented application of the filling equation, discharge "windows" as a function of tidal characteristics are developed. The windows are constrained to allow substantially all of the material discharged to exit the system during a single tidal cycle. (8 refs)

Cottrill, K. 1984. New York tidal gauge system--A US first. *The Dock & Harbour Authority* 64(757):192-193.

A $300,000 system installed in New York for automatically collecting data on tide levels is described along with other important developments in progress at the port.

Craig, P. D. 1988. A numerical model study of internal tides on the Australian Northwest Shelf. (See complete entry in Section VI.)

Cuff, W. R., and Tomczak, M., Jr., eds. 1983. *Synthesis and modelling of intermittent estuaries; A case study from planning to evaluation.* (See complete entry in Section VI.)

Dai, Z., and Zhou, Chaosheng. 1986. The fluvial process and regulation of macrotidal estuaries in China. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:644-652. University, MS: University of Mississippi.

Field data of 13 macrotidal estuaries, including those of tide, runoff, current sediment, and river morphology were collected and a preliminary review regarding the general characteristics of hydrodynamic behavior, sediment transport, and the deformation of a riverbed are presented. It is hoped that this will be helpful to the understanding of the general features of macrotidal estuaries in China. Based on the analysis of field observations, emphasis is given to the self-adjustment between water flow and river channel and the accompanying progressive siltation process subsequent to the construction of engineering works such as tidal barriers, reservoirs near the tidal limits, and large-scale reclamation projects in the estuarine region. (6 refs)

Dal Secco, S., Hauguel, A., Latteux, B., and Esposito, P. 1985. A finite element method for storm surge and tidal computation. (See complete entry in Section VI.)

Dankers, N., Binsbergen, M., Zegers, K., Laane, R., and van der Loeff, R. M. 1984. Transportation of water, particulate and dissolved organic and inorganic matter between a salt marsh and the Ems-Dollard Estuary, The Netherlands. (See complete entry in Section II.)

Davies, A. M. 1985. A three-dimensional model of the northwest European continental shelf, with application to the M_4 tide. (See complete entry in Section VI.)

Davis, R. A., Jr., Knowles, S. C., and Bland, M. J. 1989. Role of hurricanes in the Holocene stratigraphy of estuaries: Examples from the Gulf Coast of Florida. (See complete entry in Section I.)

†**Dayananda, H. V., and Gerritsen, F.** 1983. Sedimentation studies carried out on a small harbour sited in an area of high littoral drift. (See complete entry in Section II.)

†**Dean, D. M.** 1987. Effluent flow study using Rhodamine dye in Theodore Barge Canal, a tidally flushed bayou in Mobile Bay, alabama. (See complete entry in Section IV.)

de Boer, P. L., Oost, A. P., and Visser, M. J. 1989. The diurnal inequality of the tide as a parameter for recognizing tidal influences. (See complete entry in Section I.)

de Boer, P. L., van Gelder, A., and Nio, S. D., ed. 1988. *Tide-influenced sedimentary environments and facies*. (See complete entry in Section II.)

Dejak, C., Lalatta, I. M., Messina, E., and Pecenik, G. 1987. Steady-state achievement by introduction of true tidal velocities in a pollution model of the Venice Lagoon. (See complete entry in Section VI.)

Dejak, C., Lalatta, I. M., Molin, M., and Pecenik, G. 1987. Tidal three-dimensional diffusion in a model of the Lagoon of Venice and reliability conditions for its numerical integration. (See complete entry in Section VI.)

Delo, E. A., and Burt, T. N. 1986. Dispersion of sidecast dredge spoil: A mathematical prediction and field study. (See complete entry in Section V.)

Delo, E. A., and Ockenden, M. C. 1989. Prediction of siltation at a point. (See complete entry in Section VI.)

De Young, B., and Pond, S. 1989. Partition of energy loss from the barotropic tide in fjords. (See complete entry in Section I.)

Dick, G., and Siedler, G. 1985. Barotropic tides in the northeast Atlantic inferred from moored current meter data. *Deutsche Hydrographische Zeitschrift* 38(1):7-22.

Current data obtained from seven moorings in the northeast Atlantic in the course of many years are anlayzed with respect to semidiurnal barotropic and baroclinic tides and diurnal barotropic tides. For semidirunal tides M_2 and S_2, the energy distribution is usually dominated by the barotropic mode; only in a few cases does the first-order baroclinic mode contain higher energy. Barotropic tidal ellipse orientations are found to be consistent with results from earlier tide gauge observations in this area. Significant deviations occur, however, in amplitudes. Results for the diurnal component K_1 are also presented. With few exceptions, tides are found to be progressive waves in this area. The current ellipse pattern is similar to results obtained indirected by Cartwright, Edden, Spencer, et al., from tide gauge observations. (22 refs)

Dick, S. 1987. The tidal currents around the island of Sylt: Numerical investigations of the principal lunar semi-diurnal tide (M_2) (summary) (Gezeitenströmungen um Sylt. Numerische untersuchungen zur halbtägigen hauptmontide (M_2)). (See complete entry in Section VI.)

Dietrich, J., Hagstron, A., and Navntoft, E. 1983. Studies of the effect of a barrage on sedimentation. (See complete entry in Section II.)

Dijkzeul, J. C. M. 1984. Tide filters. (See complete entry in Section I.)

DiLorenzo, J. L., Huang, P.-S., and Najarian, T. O. 1989. Water quality models for small tidal inlet systems. (See complete entry in Section VI.)

†**Dixon, R. W.** 1982. Tidal and lunar data for Point Mugu, San Nicolas Island, and the Barking Sands Area during 1983. Point Mugu, California: Pacific Missile Test Center, Geophysics Division.

Basic lunar and tidal data for Point Mugu, San Nicolas Island, and the Barking Sands area during 1983 are provided. The data presented are (a) tidal data (b) times of moonrise and moonset, and (c) times of lunar phases.

†**Dixon, R. W.** 1983. Tidal and lunar data for Point Mugu, San Nicolas Island and the Barking Sands area, 1984. Point Mugu, California: Pacific Missile Test Center, Geophysics Division.

Basic lunar and tidal data for Point Mugu, San Nicolas Island, and the Barking Sands area during 1984 are provided. The data presented are (a) tidal data, (b) times of moonrise and moonset, and (c) times of lunar phases.

Doerffer, R. 1985. Observations of the suspended matter distribution dynamics in the Elbe Estuary from time series aerial photographs. *Internationale Revue der Gesamten Hydrobiologie* 70(1):127-150.

Series of aerial photographs taken with an interval of 6 minutes were used to study the dynamics of the suspended matter distribution in a 1-km section of the Elbe Estuary. The observtions show heterogeneous distribution patterns which are different at each phase of th etidal cycle. The comparison with the bathymetry indicates that the distribution is mainly a function of the riverbed topography, which modifies the local current structure. The surface distribution in the fairway region is especially determined by the ship traffic. (20 refs)

Donnell, B. P., and McAnally, W. H., Jr. 1985. Spectral analysis of Columbia River Estuary currents. (See complete entry in Section I.)

Dooley, H. D. 1979. Factors influencing water movements in the Firth of Clyde. (See complete entry in Section I.)

Douglass, S. L. 1987. Coastal response to navigation structures at Murrells Inlet, South Carolina; Main text and appendixes A and B. Technical Report CERC-87-2. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Coastal response to navigation structures at Murrells Inlet, SC, is documented. Data, which result from a postconstruction monitoring program, consist of beach, inlet, and jetty surveys; aerial photography; visual wave observations; wave buoy results; hindcast wave results; and site inspection trips. These data were collected during the period 1978-1982, approximately 5 years after jetty construction began. Beach change and wave data collected indicate that net longshore sand transport at the inlet has not been strongly to the south as previously assumed. The variability of longshore sand transport rate in time and space appears to be very important to coastal response to the jettie. Longshore transport rates are calculated from visual wave observations for 1970-1982. The direction of net transport was northward at all four wave data locations in 1979 and was toward the inlet from both sides during 1980-1982. The only wave data south of the inlet were close enough to be strongly affected by the jetties; therefore, a local reversal in net transport direction could have occurred south of the inlet during 1980-1982. Analysis of hindcast wave data for 1956-1975 indicates that the major southerly growth of the tip of Garden City in the early 1960's may have been in response to an unusually strong period of southerly sand transport. Possible modifications to the navigation project are suggested for further consideration and analysis. Improvements in the Murrells Inlet monitoring data collection program are recommended in light of the conclusions reached in this report. (21 refs)

Douvillè, J.-L., and Riaux, C.. 1986. On the dynamics of a tidal estuary: Estimation of the principal factors. (Estimation des paramètres foundamentaux de la dynamique d'un estuaire à marées). (See complete entry in Section VI.)

Draper, C. 1982. Thames Barrier Project. (See complete entry in Section V.)

Druery, B. M., and Geary, M. G. 1985. The measurement of sediment transport in N.S.W. estuaries. (See complete entry in Section II.)

Dyer, K. R. 1986. *Coastal and estuarine sediment dynamics*. (See complete entry in Section II.)

Dyson, A. R., and Druery, B. M. 1985. The impact of sand extraction on salt entrusion in the Hawkesbury River. (See complete entry in Section III.)

Elahi, K. Z., and Noor, M. A. 1983. Tidal dynamics of the Pakistani coastal water. (See complete entry in Section VI.)

Ellis, D. 1989. The Thames Estuary: A managed ecosystem. (See complete entry in Section IV.)

Emery, K. O., and Aubrey, D. G. 1986. Relative sea-level changes from tide-gauge records fo eastern Asia mainland. (See complete entry in Section VII.)

†**Engel, M.** 1976. The simulation of motions in the sea using numerical models: Applications and limitations. (See complete entry in Section VI.)

Essen, H.-H., Freygang, T., Gurgel, K.-W., and Schirmer, F. 1984. Surface currents in front of Sylt--Radar measurements in fall 1983--(Summary) (Oberflächenströmungen vor Sylt--Radarmessungen im Herbst 1983--). *Deutsche Hydrographische Zeitschrift* 37(5):201-215 (In German).

From 22 September to 4 October 1983, surface

currents, in front of Sylt, were measured by means of two radar sites. The sampling rate varied between 1/2 and 2 hours. The two-dimensional current velocities refer to a grid system with resolution of 3 km and mean extend of 30 km x 30 km. Time series are constructed with respect to different grid points. Their tidal- and wind-driven parts are estimated by least-squares methods. Beside the dominant semidiurnal tide there is also a strong quarter-diurnal tide. A linear dependence is found between the velocities of current and wind with a ratio of 0.018 and 0.012 for the northern and eastern component, respectively. The semidiurnal tidal ellipses are clearly dependent on teh topography. (8 refs)

Ewertowski, R. 1988. Mathematical model of the River Odra Estuary. (See complete entry in Section VI.)

Faas, R. W., and Carson, B. 1988. Short-term deposition and long-term accumulation of lagoonal sediment, Great Sound, New Jersey. (See complete entry in Section II.)

Fagerburg, T. L. 1989. Winyah Bay, Georgetown, South Carolina, data collection survey report. Technical Report HL-89-23. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Water levels, current speeds and directions, salinities, suspended sediment concentrations, bed sediment characteristics, and densities were measured in Winyah Bay, SC, in January 1989. The prototype data were collected as part of a study to evaluate the effects of a dredged material placement operation to create a wetland marsh in the bay. The report describes the equipment and procedures used in the data acquisition and presents tables, pltos, and summaries of all the data collected.

Falconer, R. A. 1984. A mathematical model study of the flushing characteristics of a shallow tidal bay. (See complete entry in Section VI.)

Falconer, R. A. 1985. Application of numerical models in the hydraulic design and operation of four U.K. harbours. (See complete entry in Section VI.)

Falconer, R. A. 1986. Water quality simulation study of a natural harbor. (See complete entry in Section VI.)

Falconer, R. A., and Owens, P. H. 1984. Mathematical modelling of tidal currents in the Humber Estuary. (See complete entry in Section VI.)

Falconer, R. A., and Owens, P. H. 1987. Numerical simulation of flooding and drying in a depth-averaged tidal flow model. (See complete entry in Section VI.)

Falconer, R. A., Wolanski, E., and Mardapitta-Hadjipandeli, L. 1986. Modeling tidal circulation in an island's wake. (See complete entry in Section VI.)

Fandry, C. B., Hubbert, G. D., and McIntosh, P. C. 1985. Comparison of prediction of a numerical model and observations of tides in Bass Strait. (See complete entry in Section VI.)

Farmer, D. M. 1989. Tide-induced variation of the dynamics of a salt wedge estuary. (See complete entry in Section III.)

Farrow, G. E., Allen, N. H., and Akpan, E. B. 1984. Bioclastic carbonate sedimentation on a high-latitude, tide-dominated shelf: Northeast Orkney Islands. Scotland. (See complete entry in Section II.)

Fedosh, M. S., and Munday, J. D., Jr. 1982. Satellite analysis of estuarine plume behavior. In *Oceans '82 conference record: Industry, government, education...Partners in progress,* 20-22 September 1982, Washington, DC, 464-469. Piscataway, NJ: The Institute of Electrical and Electronics Engieners, Inc.

Estuarine plumes at the Chesapeake, Delaware, and Raritan Bay entrances were studied in 268 Landsat MSS and 68 HCMM thermal infrared images. Turbidity of thermal boundaries were detected in nearly all images. Wind had a large influence on locations of boundaries: under strong southwest to west winds, plumes moved eastward from bay mouths into waste disposal areas. Northern winds, the Coriolis force, and net nontidal coastal currents drove plumes southward along the coasts from bay mouths. Plume boundaries are more dispersed during ebb tide. Seasonal effects are mixed. (30 refs)

Fields, M. L., Weishar, L. L., and Clausner, J. E. 1988. Analysis of sediment transport in the Brazos River diversion channel entrance region. (See complete entry in Section II.)

†**Fisher, C. W.** 1986. Tidal circulation in Chesapeake Bay. (See complete entry in Section VI.)

FitzGerald, D. M., and Nummedal, D. 1983. Response characteristics of an ebb-dominated tidal inlet channel. (See complete entry in Section I.)

Fleming, C. A., and Simpson, J. 1986. Studies for and design of dredging and reclamation for a new port. (See complete entry in Section V.)

Forbes, A. M. G., and Church, J. A. 1983. Circulation in the Gulf of Carpentaria; II: Residual currents and mean sea level. (See complete entry in Section I.)

Fornerino, M., and Le Provost, C. 1985. A model for prediction of the tidal currents in the English Channel. (See complete entry in Section VI.)

Franco, A. S., and de Mesquita, A. R. 1986. On the practical use in hydrography of filtered daily values of mean sea level. (See complete entry in Section I.)

Franco, A. S., and Harari, J. 1988. Tidal analysis of long series. (See complete entry in Section I.)

Franzius, O. 1986. Suspended sediment problems in the brackish transition of the tidal Ems River. (See complete entry in Section II.)

Frey, R. W., Howard, J. D., Han, S.-J., and Park, B.-K. 1989. Sediments and sedimentary sequences on a modern macrotidal flat, Inchon, Korea. *Journal of Sedimentary Petrology* 59(1):28-44.

Enormous, unbarred tidal flats fringe the west coast of Korea. Near Inchon, where spring tides range between 8 and 9 m, the intertidal expanse is more than 4 km wide. This low-energy regime results in three broadly intergradational modern subfacies: (a) an intensely bioturbated inner flat of slightly sandy mud; (b) a wavy-bedded middle flat of clayey sandy silt; and (c) a ripple-laminated outer flat of bioturbated sandy silt to silty sand. The mid-flat region is less distinctive sedimentologically than the mixed-flat subfacies of North Sea tidal flats, and flaser and lenticular bedding are rare. Well-developed intertidal drainage networks and landward salt marshes are absent. Vibracores reveal two additional sequences underneath the modern sequence, their contacts defined by scour horizons and shell concentrations. The basal sequence is characterized by irregularly oxidized, intensely to totally bioturbated argillaceous sediment with scattered wavy beds and abundant in situ plant roots. These deposits suggest a transition from a shallow subtidal or low intertidal environment to a salt marsh developed in a protected intracoastal setting. The overlying intermediate sequence also consists principally of bioturbated fine sediment with scattered wavy beds, but plant roots are absent. Stratigraphic distributions of mollusk shells and other features ally this sequence with landward parts of the modern sequence. (39 refs)

Friedrichs, C. T., and Aubrey, D. G. 1988. Nonlinear tidal distortion in shallow well-mixed estuaries: A synthesis. *Estuarine, Coastal and Shelf Science* 27(5):521-545.

The importance of asymmetric tidal cycles in the transport and accumulation of sediment in shallow well-mixed estuaries is well established. Along the US Atlantic Coast, tidal amplitude, bottom friction, and system geometry determine tidal distortion as documented at 54 tide gauges in 26 tidally dominated estuaries of varying geometry having negligible freshwater inflow. Analyses of sea surface heights are compared to the results of one-dimensional numerical modelling to clarify the physics of tidal response in well-mixed estuaries. Concise measurements of estuarine geometry and ocean tidal range are used to predict consistently the nature of tidal sea surface distortion. Numerical modelling then is utilized to extend theoretical and observational relationships between geometry and sea height to predict trends in velocity distortion and near-bed sediment transport. Nonlinear tidal distortion is a composite of two principal effects: (a) frictional interaction between the tide and channel bottoms (reflected in a/h = tidal amplitude/channel depth) causes relatively shorter floods; (b) intertidal storage (measured by V_s/V_c = volume of intertidal storage/volume of channels at mean sea level) causes relatively shorter ebbs. Variations in V_s/V_c and a/h trigger consistent and predictable changes in tidal distortion as measured through the first harmonic of the principal tidal constitutent. (36 refs)

Friligos, N. 1985. Nutrient conditions in the Euboikos Gulf (West Aegean). (See complete entry in Section IV.)

Fromme, G. A. W. 1985. The dynamics of the Keurbooms-Bitou Estuary. (See complete entry in Section I.)

Fryer, J. J., and Easton, A. K. 1980. Hydrodynamics of the Grippsland Lakes. (See complete entry in Section I.)

Furumai, H., Kawasaki, T., Futawatari, T., and Kusuda, T. 1988. Effect of salinity on nutrification in a tidal river. (See complete entry in Section III.)

Futawatari, T., Kusuda, T., Koga, K., Araki, H. Umita, T., and Furumoto, K. 1988. Development of a new simulation method for suspended sediment transport in a tidal river. (See complete entry in Section VI.)

Gade, H. G., Edwards, A., and Svendsen, H., eds. 1983. *Coastal oceanography*. (See complete entry in Section I.)

Gaillard, T. R. M. G., and Huizinga, P. 1988. Hydrodynamic model study of the Kariega and Great Fish Estuaries. (See complete entry in Section VI.)

Gardner, L. R., and Gorman, C. 1984. The summertime net transport of dissolved oxygen, salt and heat in a salt marsh basin, North Inlet, SC. (See complete entry in Section III.)

Garvine, R. W. 1987. Estuary plumes and fronts in shelf waters: A layer model. (See complete enty in Section I.)

Gerritsen, F. 1985. Tidal hydraulics - historic perspective future trends in engineering analysis. (See complete entry in Section I.)

Giese, G. L., Wilder, H. B., and Parker, G. G., Jr. 1985. Hydrology of major estuaries and sounds of North Carolina. (See complete entry in Section IV.)

Glegg, G. A., Titley, J. G., Millward, G. E., Glasson, D. R., and Morris, A. W. 1988. Sorption behaviour of waste-generated trace metals in estuarine waters. (See complete entry in Section II.)

Glen, N. C. 1984. Tidal stream data -- Presentation to the mariner. *The International Hydrographic Review* 61(2):129-136.

This article presents four main methods for the presentation of tidal stream data now in use in the UK Hydrographic Department, Ministry of Defence, Taunton, Somerset, in order of preference: (a) Tidal stream Atlases, (b) Tidal Stream Diamonds and Tables on Charts, (c) Daily Prediction of Tidal Streams in Admiralty Tide Tables, and (d) general description of Tidal Streams in Admiralty Sailing Directions. This article describes a method of obtaining tabular data for a charted diamond by the use of a long period of observations and harmonic constants and also an alternative method of using the harmonic constants in areas where the diurnal inequality is large. This latter is the only known method of presenting the data in an economic manner for areas of large diurnal inequality where the stream is rotary. (9 refs)

Godin, G. 1984. A comparison between two simultaneous sets of current measurements in the Strait of Juan de Fuca. *Estuarine, Coastal and Shelf Science* 19(4):451-461.

A comparison is made between a set of current measurements in a section across the Strait of Juan de Fuca and those recorded farther upstream at Race Rocks at a single depth. No outstanding common qualitative features are noted. Cross spectra reveal a low correlation for the subtidal current and suggest an intensification of the diurnal modulation of the flow at Race Rocks. The high correlation in the tidal bands allows calculation of this portion of the tidal current at Race Rocks which is coherent with the one sensed across the section. (11 refs)

†**Godin, G.** 1980. Cotidal charts for Canada. Manuscript Report Series No. 55. Ottawa, Canada: Department of Fisheries and Oceans.

Cotidal charts provide a visual summary of available information about the major harmonic constituents of the vertical tide.

Godin, G. 1986. The use of nodal corrections in the calculation of harmonic constants. *The International Hydrographic Review* 63(2):143-162.

The nodal corrections are effective for K_1, 0_1 and K_2. The components Q_1, J_1, 00_1, and $NO_1(M_1)$ are stabilized at sites where the tide is predominantly linear and where third-order effects are minimal. The effectiveness of the corrections for Nu_2 and Mu_2 is not apparent, but this fact has little practical importance. It is not prudent to apply any a priori corrections to $2N_2$, N_2, and L_2. S_2 may at times be modulated by its nonlinear interaction with M_2. P_1 could theoretically be modulated by its interaction with K_1, but no example of this occurrence could be found. The component M_2, which usually is the major component, exhibits much variability; it may be demodulated by the noadal corrections when the local tide is linear. The amplitude corrections for M_2 become excessive when nonlinear effects become preponderant although the phase corrections continue to help. (7 refs)

Goh, H. S., Rajendra, A. S., and Pui, S. K. 1983. Coastal problems encountered at Muara Port area in Brunei. (See complete entry in Section I.)

†**Goodrich, D. M.** 1985. On stratification and wind-induced mixing in the Chesapeake Bay. (See complete entry in Section III.)

Gotlib, V. Y., and Kagan, B. A. 1985. A reconstruction of the tides in the paleocean: Results of a numerical simulation. (See complete entry in Section I.)

Gould, D. J., Dyer, M. F., and Tester, D. J. 1986. Environmental quality and ecology of the Great Ouse Estuary. (See complete entry in Section IV.)

Granat, M. A., Brogdon, N. J., Cartwright, J. T., and McAnally, W. H., Jr. 1989. Verification of the hydrodynamic and sediment transport hybrid modeling system for Cumberland Sound and Kings Bay navigation channel, Georgia. (See complete entry in Section VI.)

Granat, M. A., Gulbrandsen, L. F., and Pankow, V. R. 1985. Reverification of the Chesapeake Bay model; Chesapeake Bay hydraulic model investigation. (See complete entry in Section I.)

Greenberg, D. A. 1987. Modeling tidal poewr. (See complete entry in Section VI.)

Griffin, D. A., Middleton, J. H., and Bode, L. 1987. The tidal and longer-period circulation of Capricornia, southern Great Barrier Reef. (See complete entry in Section I.)

†**Gross, T. F.** 1984. Tidal time dependence of geophysical turbulent boundary layers. (See complete entry in Section I.)

Guymer, I., and WEst, J. R. 1988. The determination of estuarine diffusion coefficients using a fluorimetric dye tracing technique. *Estuarine, Coastal and Shelf Science* 27(3):297-310.

An improved dye-injection technique has been used to collect new field data to study the transverse and vertical mixing in section of the Conwy Estuary. These results define the full three-dimensional spatial concentration distribution of the dye plume. Estimates of the diffusion coefficients are given and were found to be strongly influenced by the transverse shear-induced density variations and bed topography. The results suggest that an analogy with fickian diffusion appears inappropriate on flood tides because of the importance of secondary circulations during this tidal phase. (17 refs)

Hamilton, K. 1984. Detection of the lunar diurnal atmospheric tide. (See complete entry in Section I.) 112(8):1620-1625.

†**Hamilton, P., and Boicourt, W. C.** 1984. Long-term salinity, temperature and current measurements in Upper Chesapeake Bay. Raleight, NC : Science Applications, Inc.

The time and space variability ofthe salinity, temperature, and current velocity fields in the Upper Chesapeake Bay were measured. The data generated by the study are presented and the phenomena observed are described. The time series data were analyzed in terms of the major forcing mechanisms: river flow, wind, and tide. Extensive use was made of spectral and time series analysis techniques including Empirical Orthogonal Function (EOF) analysis. Conclusions and recommendations for future research using this data set are given.

Hamm, L. 1986. Analysis of the evolution of beds in the Seine Estuary (Analyse de l'evolution des fonds dans l'estuaire de la Seine). See complete entry in Sectin VI.

Hao-lin, Li, and You-fa, Xiang. 1983. A finite-element method for numerical computation of unsteady flow in estuarine branchine channels. In *International conference on coastal and port engineering in developing countries,* 20-26 March 1983, Colombo, Sri Lanka, II:1340-1354. Colombo, Sri Lanka: Conventions (Colombo) Ltd.

This paper, based on Galekin's weighted residual techniques, has deduced a finite-element method for numerical computation of unsteady flow in estuaries. With respect to space, a binodal linear element is adopted, and a weighted implicit difference method is adopted for time. By using stepping computation for branching channels and braided rivers, the large-scale set of algebraic equations is reduced to a small one only including water level at bifurcation nodes. This method has the advantage of saving on internal storage and computation time as well as facilitating programming. Finally, the numerical computational scheme was applied to the breanching estuary of Ou River for verification computations. Computations showed that the computed results agreed well with the prototype investigations and model experimental results. Based on this, project scheme computation

was conducted and the computed results obtained with teh numerical model were in fairly good agreement with the data obtained from hydraulic model experiments. (8 refs)

Harris, J. E., Hinwood, J. B., Marsden, M. A. H. Sternberg, R. W. 1979. Water movements, sediment transport and deposition, Western Port, Victoria. (See complete entry in Section II.)

Harris, P. T., and Collins, M. 1988. Estimation of annual bedload flux in a macrotidal estuary: Bristol Channel, U.K. *Marine Geology* 83(1/4):237-252.

Sedimentological data from the Bristol Channel indicate that "mutually evasive" ebb- and flood-dominant zones of net bedload transport are present. To test this hypothesis, long-term observations of currents from the channel are combined with empirical formulas to estimate annual bedload transport rates under the combined influence of tidal currents and surface wind waves. Extrapolating these values over the ebb- and flood-dominant zones, sand flux to the upper part of the channel is estimated at about 64×10^5 tons/year with supply and removal being of nearly equal magnitude. Such patterns of sand and water movement may be typical of tidally domeinated estuaries and embayments. (61 refs)

Hayes, M. O. 1983. Role of geomorphological processes in inlet and port-entrance sedimentation problems: An overview. (See complete entry in Section II.)

Healy, T., Black, K., and de Lange, W. P. 1985. Numerical model field requirements for detailed simulation of currents and sediment transport in large tidal-inlet harbours. (See complete entry in Section VI.)

Hearn, C. J. 1985. On the value of the mixing efficiency in the Simpson-Hunter h/u^3 criterion. (See complete entry in Section I.)

Hearn, C. J., and Pearce, A. F. 1985. NOAA satellite and airborne sensing of a small-scale, coastal tidal jet. (See complete entry in Section I.)

Heath, R. A. 1981. Estimates of the resonant period and Q in the semi-diurnal tidal band in the North Atlantic and Pacific Oceans. (See complete entry in Section I.)

Heath, R. A. 1981. Resonant period and Q of the Celtic Sea and Bristol Channel. (See complete entry in Section VI.)

Heath, R. A. 1983. Tidal currents in the southwestern Pacific Basin and Campbell Plateau, southeast of New Zealand. *Deep-Sea Research* 30(4A):393-409.

Tidal analyses of 7 months of hourly current meter records from nine current meters (five moorings) and 18 months of similar records at three depths, in the osuthwestern Pacific Basin (mean depth 5,000 m) near 49°30'S, 170°W, 650 km east of the Subantarctic Slope are reported. The M_2 barotropic tide has a small positive (0.06) ellipticity and is consistent with a Kelvin wave progressing anticlockwise around New Zealand. There is a distinct vertical structure in the M_2 ellipticity that decreases with depth and becomes negative below about 2,200 m. The distinct vertical structure results from superposition on the barotropic ellipse of a baroclinic ellipse (mainly the first baroclinic mode). Which must be approximately perpendicular to the barotropic ellipse, that is, approximately perpendicular to the Subantarctic Slope. The S_2 tidal ellipse has minimal vertical structure and is consistent with a free wave; the distinction between the S_2 and M_2 tides agrees with previous analyses based on tidal observations. Analysis of 7 months of hourly current meter records from the Campbell Plateau west of the top of the Subantarctic Slope indicates strong dirunal tidal currents with the relative K_1/M_2 admittance of the currents increasing by a factor of 10 from the southwestern Pacific Basin to the Subantarctic Slope. The strong diurnal currents are taken as evidence for the presence of an internal continental shelf wave on the Subantarctic Slope. (13 refs)

Heathershaw, A. D., and Codd, J. M. 1085. Sandwaves, internal waves and sediment mobility at the shelf-edge in the Celtic Sea. (See complete entry in Section II.)

Heathershaw, A. D., and Langhorne, D. N. 1988. Observations of near-bed velocity profiles and seabed roughess in tidal currents flowing over sandy gravels. (See complete entry in Section I.)

†Heinecken, T. J. E., Bickerton, I. B., Morant, P. D., Heydorn, A. E. F., and Grindley, J. R., ed. 1982. Estuaries of the Cape; Part 2: Synopses of available information on individual systems; Report 12: Buffels (WES) (CSW 1), Elsies (CSW 2), Sir Lowrey's Pass (CSW 8), Steenbras

(CSW 9), and Buffels (00S) (CSW 11). (See complete entry in Section I.)

†**Heinecken, T. J. E., comp., Heydorn, A. E. F., and Grindley, J. R., ed.** 1982. Estuaries of the Cape; Part 2: Synopses of available information on individual systems; Report 13: Silvermine (CSW 3). (See complete entry in Section I.)

Heltzel, S. B., LaGarde, V. E., and Shingler, J. H. G. 1982. Barnegat Inlet hydrographic survey comparison. In *Proceedings of the conference applying research to hydraulic pactice,* 17-20 August 1982, Jackson, MS, ed. Peter E. Smith, 707-714. New York: ASCE.

Tidal inlets are very dynamic with active sediment processes constantly remolding them. When a navigation project is required, it is very important for the design engineer to be cognizant of both short- and long-term modifications of the bathymetric nature in and surrounding the inlet. An example of such a study was a hydrographic sruvey comparison of Barnegat Inlet conducted for the US Army Engineer District, Philadelphia, by the US Army Engineer Waterways Experiment Station. The objectives of this paper are to briefly describe the computer-based data management system (DMS) used in performing the analysis for this study, and to illustrate the application of the DMS by discussing the results of the study and the problems encountered. (1 ref)

Henriques, A. G. 1986. Mathematical model for unsteady flow and sediment routing in estuaries. (See complete entry in Section VI.)

Hensley, J. M., and Briggs, M. J. 1988. Tidal elevations and currents at Ponce de Leon Inlet, Florida. Miscellaneous Paper CERC-88-8. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

Tidal elevation and current data were measured and analyzed at Ponce de Leon Inlet for use in calibrating model studies that will evaluate alternative improvements to the weir jetty system. Data were successfully obtained from 4 of 6 Sea DAta TDR-2 pressure sensors and 14 Endeco 174 current meters during the period September to November 1983. Quality of the data was excellent with very few spikes or missing points. hardware-related problems occurred on the TDR for Gage T7 due to flooding. Two of the Endeco gages at sta 2B lost their impellors due to high sediment and current flows and/or fishing activity in the inlet throat. Tidal harmonic analysis of 56 days of National Ocean Survey (NOS) tide data, using Coastal Engineering Research Center's software, verified the accuracy of the program and provided a reference for tidal elevation and current harmonic analysis results. The root mean square (rms) error was 0.11 ft. Constituent amplitudes and local epochs for 10 constituents agreed quite well with NOS's data for the full calendar year of 1974 from Daytona Beach Pier using 37 constituents. Pressure and surface elevation time series and harmonic analysis plots are presented for tidal elevation data collected in Ranges 3 through 6. Mean water depths reanged from 5.46 to 23.00 ft. The maximum tidal range was 3.5 ft at Range 4. The harmonic analysis results were very good for Ranges 3 and 4 with rms errors of 0.07 and 0.08 ft, respectively. For Ranges 5 and 6, the rms errors were higher at 0.35 and 0.28, respectively, but still very good. For the tidal current data, current roses, vector (stick) plots, current velocity magnitude time-series, current direction time-series, and harmonic analysis plots are presented. The maximum velocity recorded was 3.0 ft/sec at Range 3 for flood flow and 4.6 ft/sec at Range 2 for ebb flow. In general, these values are consistent with those reported earlier. Temperature data were remarkably consistent between TDR and Endeco gages, showing the same general trends. The range of temperatures was approximately 22.5° to 28.5° C. Conductivity data were recorded by the Endeco current meters and ranged from approximately 30 to 55 mmho/cm. (6 refs)

Herbertson, P. W. 1982. Salinity and resource development problems in East Kent. (See complete entry in Section III.)

Hinwood, J. B. 1979. Hydrodynamic and transport models of Western Port, Victoria. (See complete entry in Section VI.)

Hinwood, J. B., and Jones, J. C. E. 1979. Hydrodynamic data for Western Port, Victoria. *Marine Geology* 30(1/2):47-63.

Hydrodynamic data were obtained in Western Port to provide information about the tides and flow conditions and to estimte the bed friction coefficient and evaluate other constants necessary for calibrating a mathematical hydrodynamic model. The data collection and analysis program included meteorological data to compute wind shear at the water surface, tidal amplitude and phase from tide gauges placed at eight locations within the bay, current speed and direction profiles across seven traverse lines bounding major

segments of the bay, drogue tracking over various ebb cycles in the western and eastern entrances, and dye dispersion studies during conditions of flood and ebb phases of spring and neap tides. Dye dispersion studies were actually carried out in 1968 and the data have been used in this study. The lunar semidiurnal tide is the principal driving mechanism for the waters of the bay. Tidal range increases toward the head of the bay to a maximum of about 1.3 times the range at the entrance. Tidal lag at the head of the bay is about 2 hr. In most channels the depth-mean velocity attains a maximum of 0.6 m/sec; however, local topographic effects have a strong influence on both the velocity field and tidal lag. Under pure tidal motion there appears to be a clockwise circulation around Phillip Island and possibly French Island. Winds stronger than 10 m/sec are related to anomalous throughout the bay and also appear to exert a significant influence on the net circulation around the islands. (14 refs)

Ho, F. P., and Miller, J. F. 1982. Pertinent meteorological and hurricane tide data for Hurricane Carla. NOAA Technical Report NWS 32. Silver Spring, MD: National Weather Service, National Oceanic and Atmospheric Administration.

All available meteorological data were analyzed to provide information as accurate as possible for use in dynamic storm surge models. Detailed analyses are presented of the storm track, forward speed, central pressure, and radius to maximum wind. Particular attention is given to the period surrounding landfall. Tide gauge and high-water mark data are presented to give both a time-history and geographic depiction of the storm surge. (16 refs)

Holloway, P. E. 1985. A comparison of semidiurnal internal tides from different bathymetric locatation on the Australian North West Shelf. *Journal of Physical Oceanography* 15(3):240-251.

The vertical structure of the semidiurnal internal tide is calculated from current meter data for three locations of varying bathymetry on the southern part of the Australian North West Shelf. These results are compared to results from a previous study at a fourth location. Each site is characterized by the ratio α/c , where α is the slope of the bathymetry and $c = [(\sigma^2 - f^2)/(N^2 - \sigma^2)]^{1/2}$ is the slope of the internal wave characteristics, where σ is the wave frequency, f the inertial frequency and N the buoyancy frequency. The observations then fall into three categories: subcritical ($\alpha/c < 1$), near-critical ($\alpha/c \sim 1$), and supercritical ($\alpha/c > 1$) bottom slopes. The results at near-critical bottom slope ($\alpha/c = 1.2$) show a strong intensification of the near-bottom baroclinic currents. Observations at the supercritical slope ($\alpha/c = 1.9$) show a weak bottom intensification, and at the subcritical slopes (α/c = 0.2 and 0.5), no bottom intensification of currents is observed. The observations agree qualitatively with Wunsch's solutions for freely propagating internal waves in a wedge, except for the case $\alpha/c = 0.5$, where the weak intensificqtion predicted is not observed. (16 refs)

Holloway, P. E. 1984. On the semidiurnal internal tide at a shelf-break region on the Australian North West Shelf. *Journal of Physical Oceanography* 14(11):1787-1799.

The properties of the semidiurnal internal tide, in the region of the shelf break, at a location on the Australian North West Shelf are discussed. Information is derived from an analysis of thermistor chain and current meter data, collected over 6 months at the shelf-break and slope locations. The work is an extension of an earlier study. The internal tide is described in terms of modes, finding that the first mode dominates, propagating onshore at an angle of ~30 deg from normal to the bathymetry, with a rapid decay in amplitude of nearly five times from the shelf slope to the shelf break, a distance of 22.5 km or approximately one wavelength. The loss of energy flux from this decay gives rise to vertical mixing with a vertical eddy viscosity of 1.4×10^{-4} $m^2\ sec^{-1}$. The amplitude at the M_2 tidal frequency dominates over the S_2 amplitude giving an S_2/M_2 amplitude ratio significantly smaller than for the barotropic tidal motion. The internal tide appears to have a three-dimesnional structure at the shelf-slope location with the ratio of alongshore over onshore wave numbers ~0.8. There are large variations in amplitude of the motion with time, showing a gradual buildup in amplitude over summer, reaching a maximum at the M_2 frequency of 25 m (an average over a 14-1/2-day segment) in 123 m depth of water. The analysis results support the suggestion by Holloway that this measurement region is not the generation site for the internal tides. A region with steep bathymetric features to the northwest is suggested as a likely site. (11 refs)

Holz, K.-P., and Heyer, H. 1986. Control of sediment transport in a tidal river. (See complete entry in Section VI.)

Homsi, A. 1986. Port of Itajai and Itajai-Acu Estuary

sedimentation and erosion studies. (See complete entry in Section V.)

Huang, Z., Yuan, X, Chen, S., and Qin, H. 1986. The experimental investigation for the improvement of Modaomen Outlet of the Pearl River Estuary in China. (See complete entry in Section VI.)

Hunkins, K. 1986. Anomalous diurnal tidal currents on the Yermak Plateau. *Journal of Marine Research* 44(1):51-69.

Recent observations made over the Yermak Plateau, a 100- by 200-km submarine feature northwest of Svalbard, show that ocean currents in that area are dominated by diurnal tidal currents although semi-diurnal tidal displacements of the surface always exceed dirunal tidal displacements along the coast in the Arctic Ocean. Currents were recorded with meters suspended below two drifting ice stations, FRAM III in 1981 and RAM IV in 1982, as they traveled over several weeks from a region of abyssal depths onto the western flank of the Yermak Plateau. ice drift velcoity was calculated from satellite positions and then vectorially added to the recorded data to produce current velocity relative to the bottom. Diurnal tidal currents with spectral peaks greater than semidiurnal peaks were observed in both years with current speeds reaching 30 cm/sec over the edge of the plateau. Semidiurnal tidal currents over the middle and lower slope were principally along slope which is consistent with Kelvin wave motion. Diurnal tidal currents on the middle and lower slope were across-slope, and on the upper slope they had a clockwise rotary motion suggestive of topographic vorticity waves. These unusually large diurnal tides are apparently vorticity waves which have been resonantly forced by weakl deep-sea diurnal tides. (24 refs)

Huizinga, P. 1985. A dynamic one-dimensional water quality model. (See complete entry in Section VI.)

Huizinga, P., and Haw, P. M. 1986. A mathematical transport-dispersion model of the Knysna Estuary. (See complete entry in Section VI.)

Huizinga, P. 1984. Application of the Nrio 1-D hydrodynamic model to the Swartkops Estuary. (See complete entry in Section VI.)

Huizinga, P. 1987. Hydrodynamic model studies of the Swartvlei Estuary. (See complete entry in Section VI.)

Huizinga, P., and Gaillard, T. R. M. G. 1985. Documentation: One-dimensional hydrodynamic and water-quality model program. CSIR Report T/SEA 8507. Stellenbosch, South Africa: National Research Institute for Oceanology, Council for Scientific and Industrial Research.

This report presents the documentation of the program for the one-dimensional hydrodynamic and water quality computations. Very briefly the computational methods are described and the subroutines and the input/output units are explained. A list of symbols used in the program as well as a schematization of the input data file is given. The report also contains a complete program listing and an input data file for the Knysna model. (3 refs)

Huizinga, P., and Smith, c. J. 1987. Computation of flow through the Palmiet Estuary mouth. (See complete entry in Section VI.)

Huthnance, J. M. 1981. Large tidal currents near Bear Island and related tidal energy losses from the North Atlantic. *Deep-Sea Reserach* 28A(1):51-70.

Independent series of current meter measurements between northern Norway and Bear Island (19°E, 74 1/2°N) by MAFF Fisheries Laboratory, Lowestoft, in 1972 and the Norwegian River and Harbour Laboratory in 1978 both show a tenfold increase in diurnal tidal curernts near Bear Island. The increase appears to be due partly to excitation of a topographic mode of natural frequency less than the tidal constituent K1. Part of the increase is also due simply to the shallower water near Bear Island and is shared by teh semidiurnal tidal currents. Tidal energy fluxes out of the Norwegian Sea total about 5×10^{10} W between Norway and Bear Island and 6×10^{10} W between Bear Island and Greenland, in contrast with the observational estimate 7×10^{10} W entering the Norwegian Sea between. Scotland and Iceland. (25 refs)

Huval, C., Comes, B., and Garner, R. T., III. 1985. Ship simulation study of John F. Baldwin (Phase II) Navigation Channel, San Francisco Bay, California. (See complete entry in Section V.)

Huzzey, L. M. 1988. The lateral density distribution in a partially mixed estuary. (See complete entry in Section I.)

Hydraulics Research Station. 1981. Severn tidal power. (See complete entry in Section VI.)

Imperato, D. P., Sexton, W. J., and hayes, M. O. 1988. Stratigraphy and sediment characteristics of a mesotidal ebb-tidal delta, North Edisto Inlet, South Carolina. (See complete entry in Section II.)

Isaji, T., and Spaulding, M. L. 1987. A numerical model of the M_2 and K_1 tide in the northwestern Gulf of Alaska. (See complete entry in Section VI.)

Jagniszczak, I. 1988. Region of the Odra Estuary and its connections with the hinterland. (See complete entry in Section V.)

Jarrett, J. T. and Hensley, J. M. 1988. Beach fill and sediment trap at Carolina Beach, North Carolina. Technical Report CERC-88-7. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

The beach fill and inlet sediment trap at Carolina Beach, North Carolina, were monitored under the Monitoring Completed Coastal Projects Program. The objectives of the effort were the determination of the adequacy of the trap to serve as a primary source of beach nourishment meaterial for the project and to assess the impact of the trap on the inlet's ebb tide channel and delta. Considerable hydrographic and oceanographic data were collected and evaluated. Results of the monitoring program provided a critique of the project's performance as well as guidance on the use of sediment traps in inlets.

Jiang, J. X., and Falconer, R. A. 1985. The influence of entrance conditions and longshore currents on tidal flushing and circulation in model rectangular harbour. (See complete entry in Section VI.)

Jianghang, W., and Kaiqi, C. 1985. A hybrid method of fractional steps with L_∞-Stability for numerical modelling of harbours and bays. (See complete entry in Section VI.)

Johnson, B. H., Boyd, M. B., and Keulegan, G. H. 1987. A mathematical study of the impact on salinity intrusion of deepening the Lower Mississippi River navigation channel. (See complete entry in Section VI.)

Johnson, B. H., Trawle, M. J., and Kee, P. G. 1986. Discussion of a laterally averaged numerical model for computing salinity and shoaling with an application to the Savannah Estuary. (See complete entry in Section VI.)

Jones, D. G., Miller, J. M., and Roberts, P. D. 1984. The distribution of ^{137}Cs in surface intertidal sediments from the Solway Firth. (See compete entry in Section IV.)

Jones, M. R. 1987. Surficial sediments of the western Gulf of Carpentaria, Australia. (See complete entry in Section II.)

†Jordan, T. E., and Valiela, I. 1983. Sedimentation and resuspension in a New England salt marsh. (See complete entry in Section II.)

Joshi, M. 1986. Tide guide. *The International Hydrographic Review* 63(1):175-190.

This paper first describes and examines briefly various methods available to a navigator, port official, or operator, etc., for determining height of tide at a given time and/or the time at which the tide will attain a given (required) height in water areas which are subject to semidiurnal tides. It then introduces a new graphical method for determining these two variables (height or time). Finally, it compares the results obtained by these methods and shows that the new method gives results within acceptable limits. Because of the complete absence of calculations and ease of use, this new method should be readily acceptable to users.

Kalkwijk, J. P. T. 1985. Dispersion of matter at sea under homogeneous conditions. (See complete entry in Section I.)

Kang, Y. Q. 1984. An analytic model of tidal waves in the Yellow Sea. (See complete entry in Section VI.)

Kang, H. J., and Chough, S. K. 1982. Gamagyang Bay, southern coast of Korea: Sedimentation on a tide-dominated rocky embayment. (See complete entry in Section II.)

Kawahara, M., Hirano, H., Tsubota, T., and Inagaki, K. 1982. Selective lumping finite element method for shallow water flow. (See complete entry in Section VI.)

Kawara, O. 1988. Study on the seasonal variation of surface sediment composition in estuaries. (See complete entry in Section II.)

Kelly, L. R., and Andrews, J. C. 1985. Numerical models for planning coastal circulation studies. (See complete entry in Section VI.)

Kendrick, M. P., Derbyshire, B. V., and Stevenson, T. A. 1985. Harbor siltation - Physical model and computational studies to establish present cause and predict post-development siltation rates. (See complete entry in Section VI.)

Kennedy, V. S., ed. 1984. *The estuary as a filter.* (See complete entry in Section VI.)

Kerchaert, P., Roovers, P. P. L., Noordam, A., and De Candt, P. 1986. Articificial beach nourishment on Belgian East Coast. (See complete entry in Section II.)

Ketchum, B. H., ed. 1983. Ecosystems of the world 26: Estuaries and enclosed sea. (See complete entry in Section I.)

Keulegan, G. H. 1989. Estuary numbers. (See complete entry in Section III.)

Kikukawa, H., and Ichikawa, H. 1984. An improveed explicit finite element method for tidal flow. (See complete entry in Section VI.)

Kilset, K., and Heiberg, A. 1988. Evaluationof the "Fugacity" (FEQUM) and the "EXAMS" chemical fate and transport models: A case study on the pollution of the Norrsundet Bay (Sweden). (See complete entry in Section VI.)

Kineke, G. C., and Sternberg, R. W. 1989. The effect of particle settling velocity in computer suspended sediment concentration profiles. (See complete entry in Section VII.)

Kineke, G. C., Sternberg, R. W., and Johnson, R. 1989. A new instrument for measuring settling velocities in situ. (See complete entry in Section VII.)

King, I. P., Granat, M. A., and Ariathurai, C. R. 1986. An inundation algorithm for finite element hydrodynamic and sediment transport modeling. (See complete entry in Section VI.)

Knebel, H. J. 1989. Modern sedimentary environments in a large tidal estuary, Delaware Bay. *Marine Geology* 86(2/3):119-136.

Data from an extensive grid of sidescan-sonar records reveal the distribution of sedimentary environments in the large, tidally dominated Delaware Bay Estuary. Bathymetric features of the estuary include large tidal channels under the relatively deep (>10-m water depth) central part of the bay, linear sand shoals (2- to 8-m relief) that parallel the sides of the tidal channels, and broad, low-relief plains that form the shallow bay margins. The two sedimentary environments that were identified are characterized by either (a) bedload transport and/or eerosion or (b) sediment reworking and/or deposition. Sand waves and sand ribbons, composed of medium to coarse sands, define sites of active bedload transport within the tidal channels and in gaps between the linear shoals. The sand waves have spacings that vary from 1 to 70 m, amplitudes of 2 m or less, and crestlines that are usually straight. The orientations of the sand waves and ribbons indicate that bottom sediment movement may be toward either the northwest or southeast along the trends of the tidal channels, although sand-wave asymmetry indicates that the net bottom transport is directed northwestward toward the head of the bay. Gravelly, coarse-grained sediments, which appear as strongly reflective patterns on the sonographs, are also present along the axes and flanks of the tidal channels. These coarse sediments are lag deposits that have developed primarily where older strata were eroded at the bay floor. Conversely, fine sands that compose the linear shoals and muddy sands that ocver the shallow bay margins appear mainly on the sonographs either as smooth featureless beds that have uniform light to moderate shading or as mosaics of light and dark patches produced by ariations in grain size. These acoustic and textural characteristics are the result of sediment deposition and reworking. Data from this study (a) support the hypothesis that bed configurations under deep tidal flows are functions of current velocity, sediment size, and depth; (b) suggest criteria that could be used to distinguish between open estuarine tidal deposits in the geologic record; and (c) provide a guide to future utilization of the bay floor. (37 refs)

Knebel, H. J., Fletcher, C. H., III, and Kraft, J. C. 1988. Late Wisconsinan-Holocene paleogeography of Delaware Bay; A large coastal plain estuary. *Marine Geology* 83(1/4):115-133.

Analyses of an extensive grid of seismic reflection profiles along with previously published core data and modern sedimentary environment information from surrounding coastal areas permit on outline of the paleogeography of the large Delaware Bay Estuary during the last transgression of sea level. During late Wisconsinan times, the Delaware River system eroded a dendritic drainage pattern into the gravelly and muddy sands of Tertiary and younger age beneath the southern half of the lower bay area.

This system included the trunk valley of the ancestral river and a large tributary valley formed by the convergence of secondary streams along the Delaware coast. The evolution of the estuary from this drainage system proceeded as follows: (a) When local relative sea level was at -50 m, the head of the tide reached the present bay-mouth area. (b) At -40 m (possibly 15,0000-12,000 years ago), the trunk valley of the drainage system was a tidal river that extended more than 30 km up the bay, and a small contiguous inlet existed at the bay mouth. (c) At -30 m (approximately 11,000-10,000 years ago), the estuary comprised two narrow passages formed by the drowning of the main and tributary river valleys, and the bay-mouth inlet was 5-6 km wide. (d) At -20 m (between 8,000 and 7,000 years ago), the two passages of the estuary were joined, except for a series of small islands on top of a low intervening ridge, and the inlet channel was 11 km wide. (e) At -10 m (between 6,000 and 5,000 years ago), the estuary was nearly continuous and encompassed about 60 percent of the present lower bay area. Thin, coasre-grained fluvial deposits accumulated initially within the main channels of the former drainage system as base level was elevated by rising sea level. During the subsequent development of the estuary, clayey silts were deposited rapidly beneath the nontidal estuarine depocenter (turbidity maximum) as it migrated through the bay area, and organic muds accumulated in tidal wetlands that occupied the mouths of tributaries and small marginal embayments. As the fetch and tidal prism of the estuary increased, narrow barrier and headland beaches, composed of fine to coarse sands, were formed locally along the bay shorelines. In the late stages of development, sediment scour, reworking, and transport became the dominant processes within the open estuary. Data from this study demonstrate the great temporal and spatial variability of sedimenttary deposits within large drowned river-valley estuaries and outline a model that can be used to interpret ancient estuaries strate. (53 refs)

Koblinsky, C. J. 1981. The M_2 tide on the West Florida Shelf. *Deep-Sea Research* 28A(12):1517-1532.

The M_2 tide on the West Florida Shelf was analyzed with data from five arrays of current meter and bottom pressure sensors spanning a 2-year period. The observations of the tidal fluctuations are consistent with a linear barotropic flow model. Internal tides do not contribute significantly to the variance. Consequently, the tidal currents do not change substantially ($\pm$25 percent) over the course of a year and the temperature fluctuations are caused by horizontal advection of the mean thermal gradients. Estimates of energy flux onto the shelf revealed that energy propagates at an angle oblique to the wave crests. The dissipation of tidal energy occurs primarily near shore (depth <50 m), where the quadratic drag law for bottom friction with drag coefficient $\gamma = 0.002$ underestimates the observed dissipation rate. The energy loss over the midshelf region is small and consistent with a drag coefficient of 0.002. A one-dimensional model was developed to predict tidal sea level and current amplitudes across the shelf. The model requires only the coastal sea level and the cross-shelf topography. Results of the model are consistent with the observed tidal coefficients. (24 refs)

†Koop, K., comp., Heydorn, A. E. E., and Grindley, J. R., ed. 1982. Estuaries of the Cape; Part 2: Synopses of available information on individual systems; Report No. 18: Bot/Kleinmond System (CSW 13). (See complete entry in Section I.)

Kranck, K. 1984. The role of flocculation in the filtering of particulate matter in estuaries. (See complete entry in Section II.)

Ku, L.-F. 1985. Modulation factors in tidal prediction. (See complete entry in Section I.)

Kuiper, J., de Wilde, P., and Wolff, W. 1984. Effects of an oil spill in outdoor model tidal flat ecosystems. (See complete entry in Section VI.)

Kuo, C. Y., and Talay, T. A. 1986. Characteristics vector analysis of remote sensing data for estuarine sediments. (See complete entry in Section II.)

Lafuente, J. G., Almazan, J. L., Castillejo, F., Khribeche, A., and Hakimi, A. 1990. Sea Level in the Strait of Gibraltar: Tides. *International Hydrographic Review* 67(1):111-125.

A network of tide gauges with eight observation recording points was in operation in the Strait of Gibraltar during the years 1984 and 1985, which made it possible to draw up detailed charts of the tides showing their refined structure. For the first order, the Strait of Gibraltar represents the nodal line of the stationary wave of the western Mediterranean, which, hypothetically, would end at the Cadiz meridian (6°17'0" W). The tide is basically semi-diurnal. On average, 90 percent of the energy is associated with the second order; and for this, the

Strait of Gibraltar tends to represent an antinode of the stationary wave, although the influence of the bottom topography and the rotation are interpreted in phase delays in he sill area (slightly progressive wave) and in increased nonlinear constituents of higher orders. The radiational tide S_2 is evaluated in the area studied, and it is ascertained that it shows the same characteristics as the tides having strictly gravitational constituents, which implies that it is fundamentally co-oscillating. Order 4 displays characteristics of resonant amplification due to the existence of the free oscillation mode of the western Mediterranean basin, the period of which is close to 6 hr. Of order 3 it should be stressed that M_3, though small, is perfectly detectable in the area. (13 refs)

Lambiase, J. J. 1980. Hydraulic control of grain-size distributions in a macrotidal estuary. (See complete entry in Section II.)

Lanyon, J. A., Eliot, I. G., and Clarke, D. J. 1982. Observations of shelf waves and bay seiches from tidal and beach groundwater-level records. (See complete entry in Section VII.)

Lavelle, J. W., Massoth, G. J., and Crecelius, E. A. 1986. Accumulation rates of recent sediments in Puget Sound, Washington. (See complete entry in Section II.)

Lee, J. K., Schaffranek, R. W., and Baltzer, R. A. 1989. Convergence experiments with a hydrodynamic model of Port Royal Sound, South Carolina. (See complete entry in Section VI.)

Leendertse, J. J. 1988. Influence of the advection term approximation on computed tidal propagation and circulation. Rand Note N-2700-NETH. Santa Monica, CA: The Rand Corporation.

This note investigates the influence of the advection term approximation on computed tidal propagation and tide-induced residual circulation. The spatial reprsentation of the advection term has considerable influence on computed tidal proagation. Inclusion of this term reduces the energy in the semidiurnal tide and transfers it to other modes. The most primitive approximation appears to be the most effective. The spatial reprsentation of the advection term influences the computed intensities of the tidal-induced residual circulations. The experiments show that these circulations are induced mainly by advection. The choice of approximation of the advection terms near land-water boundaries influences the tidal propagation. (7 refs)

†**Leendertse, J. J.** 1981. SIMSYS2D: A two-dimensional flow and water quality simulation system. (See complete entry in Section VI.)

†**Leendertse, J. J.** 1982. The relation between the semidiurnal tide in the Eastern Scheldt and its overtides. (See complete entry in Section I.)

Leendertse, J. J. 1984. Verification of a model of the Eastern Scheldt. (See complete entry in Section VI.)

Leendertse, J. J., Langerak, A., and de Ras, M. A. M. 1981. Two-dimensional tidal models for the Delta Works. (See complete entry in Section VI.)

Leffler, M. W., Smith, E. R., and Mason, C. 1986. 1984 nearshore surveys and sediment sampling, Assateague Island, Maryland. Miscellaneous Paper CERC-86-5. Vicksburg, MS: US Army Engineer Waterways Experiment Station.

By collecting cross-island and nearshore profiles and sediment samples, an erosion control study of the northern Assateague Island area was developed. Comparisons were made with the profile data collected in 1965 and 1979. The Field Research Facility's Interactive Survey Reduction Program was used to edit, list, and plot the profile data. The 104 sediment samples were analyzed using standard sieve analysis techniques, and listings and plots of the size distributions are given. These plots show large and interesting changes which have occurred within the study area. Extensive growth of Ocean City Inlet's ebb tidal delta between 1965 and 1979 is clarly indicated. South of the inlet, the island shows wholesale transgression of the entire profile, while farther south the contour remains relatively stable.

Li, C. W., Lee, J. H-W., and Cheung, Y. K. 1986. Mathematical model study of tidal circulation in Tolo Harbour, Hong Kong: Development and verification of a semi-implicit finite element scheme. (See complete entry in Section VI.)

Lill, C. C., and Braddock, R. D. 1980. The evaluation of tide well constants. (See complete entry in Section VI.)

Lin, B. N., Han, Z. C., Sun, H. B., Zhou, J. D.,

He, S. L., and Wang, L. X. 1986. Two-D simulation of sediment transport and bed deformation by tides. (See complete entry in Section II.)

Lin, H.-C. J., and Martin, W. D. 1989. Newport News channel deepening study, Virginia; Numerical model investigation. (See complete entry in Section VI.)

Lincoln, J. M., and Fitzgerald, D. M. 1988. Tidal distortions and flood dominance at five small tidal inlets in southern Maine. (See complete entry in Section I.)

Liu, J. 1986. A study on the siltation in the approach channel with different alignments of the Lianyun Harbour. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III:539-541. University, MS: University of Mississippi.

The Lianyun Harbor, located in the northern part of Jiangsu Coast, is one of the important foreign trade ports of China. in recent years, because of the development of the national economy and foreign trade affairs, the extension of the harbor has beocme extremely necessary. As the harbor is situated on a silty shoal, the siltation of the harbor basin and the approach channel has postponed the extension project. In order to clarify this and other problems, the law of siltation has been investigated in the harbor basin and the approach channel. This paper is one of the research items. According to the field survey, the siltation in the channel is formed mainly by the deposition of suspended load moving back and forth on the nearby shoal under the combined action of wind wave and tidal current. (2 refs)

†Lorant, F. I. 1981. Truro hydrotechnical study: A tidal flood plain analysis. (See complete entry in Section I.)

Lowery, T. A. ed. 1987. *Symposium on the natural resources of the Mobile Bay Estuary.* (See complete entry in Section V.)

Lung, W.-S. 1986. Assessing phosphorus control in the James River Basin. (See complete entry in Section VI.)

Lung, W.-S. 1988. The role of estuarine modeling in nutrient control. (See complete entry in Section VI.)

McCave, I. N. 1979. Tidal currents at the North Hinder Lightship, southern North Sea: Flow directions and turbulence in relation to maintenance of sand banks. *Marine Geology* 31:101-114.

Current measurements were made 0.8 m above the bed and 10 m below the surface in order to determine the pattern of the tidal curents and whether there was any evidence for the secondary helical flow structure which has been suggested to be responsible for maintenance of sandbanks. Current directions do not conform to the pattern expected for a helical secondary flow but do agree with the pattern expected for Ekman veering. Current speeds agree with Van Veen's 5th-root parabolic profile. Turbulent intensities measured in the horizontal plane only are higher during decelerating tidal flow. If this corresponds to relatively higher shear stress, then sand transport during deceleration tidal flow. If this corresponds to relatively higher shear stress, then sand transport during deceleration should be greater than during acceleration and residual sand transport will be at an angle to the axis of the tidal ellipse. In this case the whole ellipse is at 10 deg to the bank axis probably giving crossbank sand transport. (29 refs)

†**MCCoy, S. E., and Watson, W. A.** 1984. Georgia estuaries circulation survey. (See complete entry in Section I.)

McLaren, P., and Little, D. I. 1987. The effects of sediment transport on contaminant dispersal: An example from Milford Haven. (See complete entry in Section IV.)

†**McMillan, D. J., and Lynn, N. M.** 1983. Fieldwork report: Medway Estuary, 28 June-18 July, 1983. Greenwich, London, England: Royal Naval College, Department of Nuclear Science and Technology.

Two tide gauges were deployed in an estuary for testing against the standard tide gauge. High-speed axial profiles were obtained. Monitoring of dye, fixed-point monitoring of water parameters, and monitoring of wind were carried out. The field work was undertaken to test equipment and procedures in the field, to test the capabilities of an inflatable craft, to obtain information to improve the project's computer modelling technique, and to gain information for validation of a one-dimensional transient estuary model.

McTamany, J. E. 1982. Evaluation of physical and numerical hydraulic models, Masonboro Inlet, North Carolina. (See complete entry in Section VI.)

Maas, L. R. M., and van Haren, J. J. M. 1987. Observations on the vertical structure of tidal and inertial currents in the central North Sea. *Journal of Marine Research* 45(2):293-318.

Tidal and inertial current ellipses, measured at several locations and depths in the central North Sea during a number of monthly periods in 1980, 1981, and 1982, are decomposed into counterrotating, circular components to which Ekman dynamics are applied to determine Ekman layer depths and vertical phase differences, from which are inferred overall values of the eddy viscosity and drag coefficient. Stratification effects produce an additional vertical phase shift of the anticyclonic rotary component, indicative of an inverse proportionality of the eddy viscosity to the vertical density gradient. From the time variations of the Ekman layer dpeths of the semidiurnal tidal components, as well as from the vertical structure of the inertial current component are inferred variations in the relative vorticity of the low-frequency flow. (28 refs)

Marche, C., Quach, T. T., and Prud'homme, J. 1989. The tides effects on the dam break flood wave. (See complete entry in Section VI.)

Marmorino, G. O. 1983. Summertime coastal currents in the northeastern Gulf of Mexico. (See complete entry in Section I.)

Marsden, M. A. H. 1979. Circulation patterns from seabed-drifter studies, Western Port and Inner Bass Strait, Australia. (See complete entry in Section I.)

Marsden, M. A. H., Mallett, C. W., and Donaldson, A. K. 1979. Geological and physical setting, sediments and environments, Western Port, Victoria. (See complete entry in Section II.)

Marsden, R. F. 1986. The internal tide on Georges Bank. *Journal of Marine Research* 44(1):35-50.

Data from a section of eleven current meters oriented across isobaths at three locations on Georges Bank were examined. On the bank, the M_2 tidal currents were barotropic and were in close agreement with the Greenberg numerical model of the Gulf of Maine. On the slope, the M_2 tidal current contained 70° phase shifts for 35-m changes in depth. The results from the model were used to separate currents due to the internal and surface tides. It was found that amplitude of the tidal velocities associated with the baroclinic component of the internal tide were as large as for the estimated barotropic tidal velocities. The eddy and mean heat fluxes off the bank were calculated. The depth-averaged heat flux due to the mean currents was statistically zero. The eddy heat flux on the slope was significant and was in a direction consistent with a transport of scalar properties on to the bank. A harizontal diffusion coefficient of 290 m^2/sec was calculated. The maximum eddy flux occurred immediately below the thermocline on the bank slope at a depth of large temperature inversions. It is suggested that a breaking internal tide plays a large role in determining across-isobath scalar transports. (18 refs)

Mayer, D. A., Leaman, K. D., and Lee, T. N. 1984. Tidal motions in the Florida current. (See complete entry in Section VI.)

Mehta, A., and Maa, P.-Y. 1986. Waves over mud: Modeling erosion. (See complete entry in Section VI.)

Mehta, A. J., Partheniades, E., Dixit, J. G., and McAnally, W. H. 1982. Properties of deposited kaolinite in a long flume. (See complete entry in Section VI.)

Miles, G. V., and Cooper, A. J. 1985. Application of a DAP computer to tidal problems. (See complete entry in Section VI.)

Milne, R. A., Nicholas, P. C., Pattinson, C., and Halcrow, W. 1986. The definition of effluent discharge consent conditions in complex estuarine environments. (See complete entry in Section IV.)

†**Morant, P. K., Bickerton, I. B., Heydorn, A. E. F., and Grindley, J. R. ed.** 1983. Estuaries of the Cape; Part 2: Synopses of available information on individual systems; Report 19: Groot (WES) (CMS 23) and Sout (CMS 22). (See complete entry in Section I.)

†**Morant, P. D., and Grindley, J. R., comps.** 1982. Estuaries of the Cape: Part 2: Synopses of available information on individual systems; Report 14: Sand (CSW 4). (See complete entry in Section I.)

Moses, J. E., and Blair, C. 1988. Prediction of tidal surge in lower Chesapeake Bay. (See complete entry in Section I.)

Müller, K.-D., and Schwarze, H. 1988. Some studies to reduce sedimentation in a port on a tidal river. (See complete entry in Section II.)

Murphy, P. P., Bates, T. S., Curl, H. C., Jr., Feely, R. A., and Burger, R. S. 1988. The transport and fate of particulate hydrocarbons in an urban fjord-like estuary. *Estuarine, Coastal and Shelf Science* 27(5): 461-482.

Hydrocarbon concentrations were measured on suspended particulates and on surficial marine sediments in the urban fjord-like estuary of Puget Sound, Washington. These data were combined with sediment deposition rates, suspended particulate concentrations, and circulation data to assess hydrocarbon distributions and fates. Evaluation of major sinks for petroleum hydrocarbons (UCM) and polycyclic aromatic hydrocarbons (PAH) in an urban estuary indicates that >90 percent of the hydrocarbons which are associated with suspended particulates in the main basin of Puget Sound are deposited in the estuarine sediments. Approximately 63 percent of the PAH and 100 percent of the UCM associated with particles in the main basin settle directly to the sediments. The remainder is carried to the main basin sediments via horizontal transport from other areas. Trends in PAH ratios are used to identify major sources of PAH. Estimates sources of PAH are balanced by the estimated sinks. (53 refs)

Nadeau, J. E., and Hall, M. J. 1988. Distribution patterns of metals in sediments of the Great Sound Complex, New Jersey. (See complete entry in Section II.)

Naik, A. S., Kanhere, V. N., and Vaidyaraman, P. P. 1983. Effect of salinity on siltation in the Cochin Port. (See complete entry in Section III.)

Nece, R. E. 1985. Physical modeling of tidal exchange in small-boat harbors. (See complete entry in Section VI.)

Nelissen, H. A. M. 1986. Foundation of the Eastern Scheldt storm surge barrier. (See complete entry in Section V.)

New, A. L., Dyer, K. R., and Lewis, R. E. 1986. Predictions of the generation and propagation of internal waves and mixing in a partially stratified estuary. *Estuarine, Coastal and Shelf Science* 22(2):199-214.

A period of intense mixing, causing an increase in the salinity of the surface layer from 2 percent to 7 percent, occurs during the ebb tide in the upper reaches of the Tees Estuary. This follows the passage of internal waves of 1 - to 2-min period. Assuming an upstream direction of propagation, the measurements indicate that the internal waves would have been released on the previous ebb tide. The waves, which would then advect with the ensuing flood, could break and cause the mixing period. However, the waves may alternatively travel downstream, and other mechanisms may be responsible for the mixing. It may be, for instance that the mixing was generated at one of two bridges 2-3 km upstream from the observation station, and then advected downstream on the ebbing tide. Further studies are needed to clarify the situation. (17 refs)

Nichols, M. M. 1986. Storage efficiency of estuaries. (See complete entry in Section II.)

Nihoul, J. C. J., and Jamart, B. M., ed. 1987. *Three-dimensional models of marine and estuarine dynamics*. (See complete entry in Section VI.)

Nguyen, K. D., and Martin, J.-M. 1988. A two-dimensional fourth-order simulation for scalar transport in estuaries and coastal seas. (See complete entry in Section VI.)

Nuttall, P. M., Richardson, B. J., and Condina, P. 1989. Effects of saline flushing to a polluted estuary to enhance water quality standards. (See complete entry in Section III.)

Odd, N. V. M. 1981. The predictive ability of one-dimensional estuary models. (See complete entry in Section VI.)

Oenema, O., and DeLaune, R. D. 1988. Accretion rates in salt marshes in the Eastern Scheldt, Southwest Netherlands. (See complete entry in Section III.)

Oey, L.-Y., Mellor, G. L., and Hires, R. I. 1985. A three-dimensional simulation of the Hudson-Raritan Estuary; Part II: Comparison with observation. (See complete entry in Section VI.)

Oey, L.-Y., Mellor, G. L., and Hires, R. I. 1985. A three-dimensional simulation of the Hudson-Raritan Estuary; Part III: Salt flux analyses. (See complete entry in Section III.)

Oey, L.-Y., Mellor, G. L., and Hires, R. I. 1985.

Tidal modeling of the Hudson-Raritan Estuary. (See complete entry in Section VI.)

Officer, C. B., Lynch, D. R., Setlock, G. H., and Helz, G. R. 1984. Recent sedimentation rates in Chesapeake Bay. (See complete entry in Section II.)

O'Keeffe, P., and Harding, P. 1985. The combined use of mathematical and physical models to represent the tidal behaviour of Gladstone Harbour. (See complete entry in Section VI.)

Olson, P. 1986. The spectrum of subtidal variability in Chesapeake Bay circulation. (See complete entry in Section I.)

†**O'Neil, C. S.** 1985. A proposed standard method for measuring low turbidities and a procedure for predicting particle size distribution from light scattering data. Ph.D. diss. University of Kansas, Lawrence.

Thirty-nine samples of fresh, estuarine, and marine water were collected from the Chesapeake Bay-Hampton Roads area. The following data were obtained from each sample: the volume scattering function of three small angles and three large angles at wavelengths of 436,546, and 578 nm; the total extinction, scattering, and absorption coefficients; turbidity in FTU; suspended solids; and particle size distribution from 0.79 to 101.6 micrometers equivalent spherical radius. The total scattering coefficient measured in units of m^{-1} correlates well with the current standard turbidity measurement for the sastudied, and has the advantage of being expressed in absolute physical units rather than in terms of a calibration standard as is the current practice. However, suitable equipment for plant operation is not commercially available for measuring the total scattering coefficient. The volume scattering function of 45 deg, $\beta(45)$, has been shown to be theoretically related to the total scattering coefficient; this has been confirmed experimentally. It is recommended that turbidity be measured as $T_{45} = 30\ \beta(45)$, $m^{-1}\ sr^{-1}$ where the constant 30 is used to amplify the volume scattering function to a magnitude which approximates the values of both the current turbidity measurement and the total scattering coefficient. It was found that a single refractive index is not adequate to describe particles in natural waters. A collection of 23 model scattering curves for particles ranging from 0.50 to 101.6 micrometers radius for each of six refractive indices can be used with a procedure which matches calculated scattering profiles to experimental scattering profiles to predict particle size distributions in natural waters. On the basis of the estimated error in the total experimental absorption coefficient, one of two collections of six refractive indices can be used to predict a particle size distribution which will yield a thtal theoretical extinction coefficient within ± 30 percent of the total experimental extinction coefficient for 95 percent of the samples.

Orbi, A., and Salomon, J.-C. 1988. Tidal Dynamics in the vicinity of the Channel Islands. (See complete entry in Section VI.)

Osonphasop, C., and Hinwood, J. B. 1984. On measurement of turbulence and shear stresses in tidal currents. In *Proceedings of the fourth congress of Asian and Pacific Regional Division of the international Association for Hydraulic Research,* 11-13 September 1984, Chiang Mai, Thailand, I:339-353. Bangkok, Thailand: International Association for Hydraulic Research, Asian and Pacific Divison.

Field measurements of turbulent velocity fluctuations in three coordinate directions were simultaneously collected at various elevations from the seabed to cover the major portion of the water depth. The turbulence for the major portion of the water depth was apparently anisotropic in the low wave number range. The Reynolds stresses and eddy viscosity values were found to vary with the mean flow, with maximum values at around 2 m above the seabed, then significantly drop at increasing distances above the seabed. The drag coefficient and roughness length were evaluated and appeared to be insensitive to the different shape and size of sand dunes. Their mean values were found to agree with those obtained from the logarithmic profile of mean velocities and other studies. (24 refs)

Ostendorf, D. W. 1984. Linearized tidal friction in uniform channels. (See complete entry in Section I.)

Otsubo, K., and Muraoka, K. 1985. Resuspension rate function for cohesive sediments in stream. (See complete entry in Section II.)

Otvos, E. G. Barrier Island formation through nearshore aggradation--Stratigraphic and field evidence. (See complete entry in Section I.)

Outlaw, D. G., and Butler, H. L. 1982. Model verification using tidal constituents. (See complete entry in Section VI.)

Oyegoke, E. S., Osoba, E. B., Oladapo, O. O., Uzochukwu, B. N., and Ibrahim, A. 1983.

Coastal erosion problems in Nigeria and some measures adopted over the years for their solution. (See complete entry in Section V.)

Owens, N. J. P. 1986. Estuarine nitrification: A naturally occurring fluidized bed reaction? (See complete entry in Section VI.)

Park, J. K., and James, A. 1986. Modeling of pollutant dispersion in stratified oscillatory flows. (See complete entry in Section VI.)

Park, J. K., and James, A. 1988. Time-varying turbulent mixing in a stratified estuary and the application to a Lagrangian 2-D model. *Estuarine, Coastal and Shelf Science* 27(5):503-520.

Tracer tests and hydrodynamic surveys were carried out in the partially stratified Tyne Estuary to investigate transverse and vertical turbulent mixing. Time-varying vertical turbulent diffusivity, K_z, and viscosity, N_z, over a tidal cycle were evaluated from the laterally averaged mass balance and momentum equations. Time-varying K_z values estimated were found to have negative logarithmic correlation with Ri but not clear correlation with $\Delta S/S$. Equations of K_z and N_z having semidiurnal periods were proposed from the evaluation of the reported equations and field observation in the Tyne Estuary and applied to a laterally averaged Lagrangian two-dimensional model for predicting the vertical salinity and velocity profiles in the Tyne Estuary. (26 refs)

Park, Y.-H. 1986. Semidiurnal internal tides on the continental shelf off Adbidjan. (See complete entry in Section I.)

Paterson, D. M. 1989. Short-term changes in the erodibility of intertidal cohesive sediments related to the migratory behavior of epipelic diatoms. (See complete entry in Section II.)

Pearson, C. A., Schumacher, J. D., and Muench, R. D. 1981. Effects of wave-induced mooring noise on tidal and low-frequency current observations. *Deep-Sea Research* 28A(10):1223-1229.

Because of the controversy over the effects of surface wave motion on current records, summer and winter M_2 tidal current speeds measured by Aanderaa current meters on subsurface moorings from several locations on the Gulf of Alaska and Bering Sea continential shelf were compared. Seasonal differences were slight and in most cases not significantly correlated with observed mean wave height measured at Buoy EB-03. It was concluded that the seasonally averaged low-frequency currents measured by Aanderaa current meters on moorings with the float at least 18 m below the surface were not seriously contaminated by surface-wave-induced mooring motion. (7 refs)

Pearson, C. E., and Winter, D. F. 1984. On tidal motion in a stratified inlet, with particular reference to boundary conditions. *Journal of Physical Oceanography* 14(8):1307-1314.

The method of characteristics is used to provide radiation-type boundary conditions appropriate to a portion of a two-layer inlet subject to tidal effects governed by one-dimensional shallow-water theory. Internal waves are considered, with Knight Inlet as an example. (16 refs)

Pejrup, M. 1988. Suspended sediment transport across a tidal flat. (See complete entry in Section II.)

Pelegrì, J. L. 1988. Tidal fronts in estuaries. (See complete entry in Section I.)

Perillo, G. M. E., and Ludwick, J. C. 1984. Turbulence measurements over a sand wave in Lower Chesapeake Bay, Virginia. *Marine Geology* 59(1/4):283-304.

Measurements of turbulent shear stress 5 cm above a sediment bed are described for five stations distributed along a transverse profile of an estuarine sand wave in lower Chesapeake Bay, Virginia, U.S.A. Time series analyses of the velocity data reveal three kinds of constituents: (a) components of long period; (b) wind wave components; and (c) turbulence. The energy in the turbulent part of the records is highly attenuated in comparison with that of the low-frequency components. Furthermore, at all except the lowermost frequencies, the energy contained in the horizontal component of the flow is less than that contained in the vertical component. The excess energy at the low-frequency part of the spectrum as compared to the high-frequency part is explained by (a) the input of energy from wind waves; (b) damping of turbulence; or (c) both causes. The first evidently is the main cause. Suspended sediments and stable density stratification reduce turbulence, but they act mainly on the vertical component. A schematic model, presented here, indicates that oscillating flow over a rugose bed induces additional fluctuations in the vertical compenent. Estimtes of Reynolds shear stress are small and most are

negative. Time series plots of the Reynolds stress show (a) small spikes in all records in which the instantaneous shear stresses are very close to zero; and (b) intermittent large spikes. In most instances, within a spike, the fluctuating horizontal component of the turbulent velocity u and the vertical counterpart w are of the same sign and $(w) > (u)$. These results are in agreement with the proposed model of flow over rippled surfaces. The findings and concepts developed in the study indicate that even though a flow over the bed actually produces a significant boundary shear stress, it cannot be properly measured very close to the bottom based on the Reynolds stress idea. When making near-bed measurements in turbulent flows in open waters with tidal currents, surface waves, stable density structures, a rugose bed, and sediment in suspendsion, one may encounter a reduction in turbulence and a degradation of the usual correlation between u and w . Under these conditions the profile methos for determining the shear stress, using mean flow values, may be more reliable. (46 refs)

Perrels, P. A. J., and Karelse, M. 1981. A two-dimensional, laterally averaged model for salt intrusion in estuaries. (See complete entry in Section VI.)

Phien, H. N., and Vongvisessomjai, S. 1980. Mathematical modelling of surface discharge of heated water. (See complete entry in Section VI.)

Picaut, J., and Verstraete, J. M. 1979. Propagation of a 14.7-day wave along the northern coast of the Guinea Gulf. (See complete entry in Section I.)

Pickard, G. L. 1986. Effects of wind and tide on upper-layer currents at Davies Reef, Great Barrier Reef, during MECOR (July-August 1984). (See complete entry in Section I.)

Pingree, R. D., Mardell, G. T., and Maddock, L. 1985. Tidal mixing in the Channel Isles region derived from the results of remote sensing and measurements at sea. *Estuarine, Coastal and Shelf Science* 20(1):1-18.

Satellite images and measurements at sea have identified a pattern of tidal fringes southwest of Jersey. From the fringe separation it is possible to estimate the residual currents in the region. From the dissipation time scale of the fringes it is possible to derive a value for the nondimensional coefficient of tidal mixing. (6 refs)

†**Pirie, D. M., and Steller, D. D.** 1977. California coastal processes study--Landsat II, final report. NASA CR-153043. San Francisco, CA: US Army Engineer District, San Francisco.

This study reports on the continued use of Landsat data in the analysis and description of long- and short-term littoral and nearshore processes along the California coast. The effects of these processes on natural and mofified shorelines and the capability to demonstrate the utility of Landsat-derived information are important considerations of the US Army Corps of Engineers in coastal protection, coastal zone management, and engineering planning. The processes studied incude sediment transport, river discharge, nearshore currents, and estuarine flushing. Landsat data as well as eerial photography and surface data covering a 4-year period were analyzed to determine the variability of coastal processes. The specific objectives of this investigation included the determination of sediment transport parameters measureable in the Landsat data and application of this information to everyday coastal planning and construction. By using suspended sediments as tracers, other specific objectives were met by the qualitative definition of the nearshore circulation along the entire coast of California with special study sites at Humboldt Bay, the mouth of the Russian River, San Francisco Bay, Monterey Bay, and the Santa Barbara Channel. Although Landsat primarily imaged fines and silts in the surface waters, the distribution of sediments allow an examination of upwelling, convergences, and coastal erosion and deposition. In Monterey Bay and Humboldt Bay these coastal phenomena were used to rrace seasonal trends in surface currents. These charts may now be used as a source of basic trends and current patterns in establishing detailed surveys. Coastal managers may use these charts as a data source for planning locations of outfall structures or other coastal construction projects.

Pizzuto, J. E. 1986. Barrier island migration and onshore sediment transport, southwestern Delaware Bay, Delaware, U.S.A. (See complete entry in Section II.)

Pommeruy, M., Cormier, M., Brunel, L., and Breton, M. 1987. Bacterial flora studied in a Brittany Estuary (Élorn, rade de Brest, France) (Étude de la flore bactérienne d'un estuaire breton (Élorn, rade de Brest, France). (See complete entry in Section IV.)

Ports, M. A., ed. 1989. *Hydraulic Engineering.* (See complete entry in Section I.)

Poulet, S. A., Chanut, J.-P., and Morissette, M. 1986. Size spectra of particles in the estuary and Gulf of Saint Lawrence; I: Variations with space (Étude des spectres de taille des particules en suspension dans l'estuaire et le golfe du Saint-Laurent. I. Variations spatiales). (See complete entry in Section II.)

Prandle, D. 1985. On salinity regimes and the vertical structure of residual flows in narrow tidal estuaries. (See complete entry in Section III.)

Prandle, D. 1987. The fine-structure of nearshore tidal and residual circulations revealed by H. F. radar surface current measurements. (See complete entry in Section I.)

Prandle, D., and Rahman, M. 1980. Tidal response in estuaries. (See complete entry in Section I.)

Prinsenberg, S. J. 1988. Damping and phase advance of the tide in western Hudson Bay by the annual ice cover. *Journal of Physical Oceanography* 18(11):1744-1751.

Admittance analysis of yearlong current meter records and tidal height data shows that the annual ice cover affects the tidal currents and heights in Hudson Bay. Along the west coast of the bay, the semidiurnal tidal current and height are reduced by 10 percent and arrive 20 minutes earlier in winter than in summer. The diurnal tide shows similar characteristics, but its weaker signal does not produce as reliable and consistent results. A simple theory of a reflecting Kelvin wave in a rectangular bay predicts that the extra damping by the ice cover causes the amphidromic points to move toward the shore along which the reflecting wave travels. Thus during the winter one sees relatively more of the incident wave than the reflected wave which causes a phase advance while the sum of their amplitudes decreases. Although further numerical modeling is required to determine the exact increase in linear damping coefficient caused by the ice cover, the simple analytical theory estiamtes it to be of the saem order of magnitude as that caused by bottom friction. (13 refs)

Prinsenberg, S. J., and Bennett, E. E. 1989. Vertical variations of tidal currents in shallow land fast ice-covered regions. (See complete entry in Section I.)

Pritchard, D. W., and Vieira, M. E. C. 1984. Vertical variations in residual current response to meteorological forcing in the mid-Chesapeake Bay. In *The estuary as a filter,* ed. V. S. Kennedy, 27-65. Orlando: Academic Press.

Records of the nontidal current velocity obtained from current meters deployed for 20 days in two cross sections in Chesapeake Bay were used with an interpolation scheme to produce a vertical profile of the laterally averaged longitudinal velocity component at 1-m depth intervals at each section, at 3-hr intervals over the 15-day truncated record. Various statistical producedures were used to relate variations in the residual current at each depth to wind variations. Surface layers down to about 8 m responded directly to wind with little time lag. A slope of the water surface was also set up by the wind, with a consequent barotropic pressure force directed opposite to the wind. The current near the bottom responded first to this pressure force, flowing opposite to the wind with a phase lag of about 8 hr. This counter response proceeded up the water column, such that in the intermediate layers just below the pycnocline the negative response to the wind had a phase lag of about 20 hr. A diagnostic analytical model, based upon a Fourier transform of the linearized equations of motion, was exercised for a four-layered simulation of the vertical response of the currents to inputs of the observed fluctuations in wind and surface slope. The major features of the time variations in the residual currents in the four layers were reproduced by the model. (11 refs)

Puls, W., and Kuehl, H. 1986. Field measurements of the settling velocities of estuarine flocs. In *River sedimentation,* Proceedings of the Third International Symposium on River Sedimentation, 31 March-4 April 1986, Jackson, MS, ed. S. Y. Wang, H. W. Shen, and L. Z. Ding, III: 525-536. University, MS: University of Mississippi.

In situ measurements of the settling velocity of mud floxs were carried out in the Elbe Estuary (West Germany). It is shown how the settling velocity depends on the concentration of suspended solid matter, on the water salinity, on the grain size of mineral particles, and on the amount of combustible organic matter in the suspended solids matter. The two main findings: (a) the floc settling velocity increases with increasing solid mater concentration, (b) the floc settling velocity decreases drastically when flocs move from the limnic zone to the brackish zone of the estuary. (40 refs)

Radford, P. J., and West, J. 1986. Models to minimize monitoring. (See complete entry in Section VI.)

Ramsay, R. J., Cooper, J. A. G., Wright, C. I., and Mason, T. R. 1989. The occurrence and formation of ladderback ripples in subtidal, shallow-marine sands, Zululand, South Africa. (See complete entry in Section I.)

Readman, J. W. preston, M. R., and Mantoura, R. F. C. 1986. An integrated technique to quantify sewage, oil and PAH pollution in estuarine and coastal environments. (See complete entry in Section IV.)

Reed, D. J. 1988. Sediment dynamics and deposition in a retreating coastal salt marsh. (See complete entry in Section II.)

Riepma, H. W. 1987. Topographically induced tidal vorticity in a shallow homogeneous sea area. *Oceanologica Acta* 19(4):393-401.

This paper presents some results of current measurements that were conducted in the southern bight of the North Sea. The object of these measurements was to study topographically induced tidal vorticity experimentally, as opposed to the theoretical studies of Zimmerman. Good agreement between theory and experiment was found only for the dominant semidiurnal M_2 tidal conponent. Because of measurement errors, such an agreement could not be established for the M_4 tidal component. The motivation for this study came from earlier observations of currents in the North Sea that revealed the existence of spatial variability of tidal and residual currents. Because vorticity is defined in terms of derivatives of the horizontal-flow components, it is a measure of spatial current variability as well. (19 refs)

Rinaldo, A., and Putti, M. 1987. On tide-induced residual transport in schematic expansion. (See complete entry in Section I.)

Roberts, P. J. W. 1980. Ocean outfall dilution: Effects of currents. (See complete entry in Section IV.)

Robertson, C. I., and Shellin, R. H. 1985. A model study of tidal barrage sluices for minimum energy loss. (See complete entry in Section VI.)

Rodda, J. C., and Jones, G. N. 1983. Preliminary estimates of loads carried by rivers to estuaries and coastal waters around Great Britain derived from the harmonized monitoring scheme. (See complete entry in Section II.)

Ross, C. W., and Curtis, M. A. 1989. Comparison of techniques for ascertaining the imapct of a thermal discharge on the temperature of tidal receiving waters. *Water Science and Technology* 21(2):195-198.

Investigations were carried out over the period of 1975-85 to determine the extent and magnitude of changes in the thermal environment of the Calliope River Estuary attributable to the operation of the Gladstone Power Station. A review is given of the relative advantages and limitations of the following techniques used in the investigations: intermittent monitoring at 30 sites on 500 days over 10 years; continuous monitoring at a small number of sites; remote sensing by aircraft; and intensive sutides focussing upon determining tidal influences. Information is presented on the measured increase in river temperatures above natural background levels. The techniques provide different information and complement each other. A judicious mix of monitoring techniques is necessary to obtain a detailed assessment of thermal discharge effects due to the dynami cnature of tidal waters. (2 refs)

Saeijs, H. L. F. 1987. Towards control of a estuary. (See complete entry in Section V.)

Saiki, M., and Yanagino, T. 1984. Characteristics of the tidal current deduced from the GEK data in the eastern Chine Sea. *The Oceanographical Magazine* 34(1-2):41-45.

Historical data set of sea surface current which Geomagnetic Electro Kinetograph (GEK) instruments were statistically treated to study the properties of tidal current on the continental shelf in the eastern China Sea. In the semidiurnal component of tidal current, it was revealed that the major axis of the tidal ellipse is perpendicular to the cotidal lines of M_2 tide and the current speed reaches its peak when the sea level at Nagasaki is in high water and low water. (2 refs)

Salomão, J, M. 1987. A survey for salinity intrusion and pollution assessment in Maputo Estuary. (See complete entry in Section VII.)

Sanchez-Diaz, E., and Mehta, A. J. 1982. Dispersive transport in inlet channels: Case study. (See complete entry in Section IV.)

Santschi, P. H., Nixon, S., Pilson, M., and Hunt, C. 1984. Accumulation of sediments, trace metals (Pb,Cu) and total hydrocarbons in Narragansett Bay, Rhode Island. (See complete entry in Section IV.)

Satake, K., Okada, M., and Abe, K. 1988. Tide gauge respone to tsunamis: Measurements at 40 tide gauge stations in Japan. *Journal of Marine Research* 46(3):557-571.

The responses of tide gauges to tsunamis are examined by in situ measurements at 40 stations in northeastern Japan. Recovery of water level in the tide well is measured after the water is drained or added to create a water level difference between the inside and outside of the wells. The recovery times for a 1-m water level difference, estimated from the observations, vary from station to station and range from 65 to 1,300 sec. Tsunami wave forms on tide gauge records from the 1983 Japan Sea earthquake are corrected for the observed response. For those stations with the observed recovery times longer than 300 sec, the corrected wave forms differ significantly from the originals and reproduce the inundation heights near the tide gauge stations, indicating that the tide gauge system significantly distorted the tsunami wave forms. At such stations, the correction for the response is necessary for quantification of tsunamis. The recovery time is also computed hydraulically on the basis of the structure of the tide gauge system. The ratio of the observed time to the computed one ranges between 1 and 10, which is attributed to environmentally induced change of the tide gauge system. (27 refs)

Sauvel, J. 1982. The tidal dynamics of the western North Sea. (See complete entry in Section VI.)

Savenije, H. H. G. 1986. A one-dimensional model for salinity intrusion in alluvial estuaries. (See complete entry in Section VI.)

Savenije, H. H. G. 1988. Influence of rain and evaporation on salt intrusion in estuaries. (See complete entry in Section III.)

Saxena, P. C. 1983. Effects of reclamation of inter tidal zones in the Mahim Creek. (See complete entry in Section V.)

Schaffranek, R. W. 1982. A flow model for assessing the tidal Potomac River. (See complete entry in Section VI.)

Schmalz, R. A., Jr. 1985. Numerical model investigation of Mississippi Sound and adjacent areas. (See complete entry in Section VI.0

†**Scott, P. J.** 1986. Sufficient conditions for optimal control of multiple basin tidal power systems. Ph.D. diss., University of Toronto, Canada.

Part on e considers optimal control problems having different operating regimes, both mixed and unmixed inequality control constraints, and variable end point boundary conditions. Field-like sufficient conditions for local extrema are developed giving matrix Ricatti equations that adjust for changes in operating regimes and inequality constraints. Two types of singular boundaries are identified, having velocity data suggesting second-order equations for approaching extremals. Convexity and "nonsingular" velocity data ensure that a field exists near such boundaries. Several single-basin and multibasin tidal power systems suitable for the Bay of Fundy region are investigted in part two. Operation of single-basin systems and a double-basin central powerhouse system overa lunar tide sequence for maximum energy or maximum revenue from power sales is simulated using Pontryagin's Maximum Principle. Properties of the maximum energy operation are used to devise feedback controls for a pumped storage facility that operates in conjunction with a single- or double-basin site to prodice a high constant daytime output. Several versions of the combined system are simulated voer the lunar tide sequence and several irregular sequences to determine how the shifting occurrence of daytime affects the operation. The sufficient conditions developed in part one are applied to each of the tidal power systems considered in part two. An optimization problem is formalated for the design of multibasin tidal power systems that reduce expansion requirements of other power sources by following a specified, time-dependent normalized demand profile. Numerical data describing the tides, basin areas, and turbines used in the simulations are contained in several appendices as are descriptions of the stages required to implement Pontryagin's Maximum Principle.

Seabergh, W. C. 1976. Improvements for Masonboro Inlet, North Carolina. (See complete entry in Section V.)

Seabergh, W. C. 1985. Los Angeles and Long Beach Harbors model study; Deep-draft dry bulk export terminal, alternative No. 6: Resonant response and

tidal circulation studies. (See complete entry in Section I.)

Segar, D. A., Davis, P. G., and Stamman, E. 1984. A global comparison of contamination in populated estuaries and coastal waters. (See complete entry in Section IV.)

Seim, H. E., Kjerfve, B., and Sneed, J. E. 1987. Tides of Mississippi Sound and the adjacent continental shelf. *Estuarine, Coastal and Shelf Science* 25(2):143-156.

Hourly water level and current data were collected in Mississippi Sound and the adacent continental shelf from April 1980 to October 1981. Amplitudes and epochs of the principal tidal constituents were calculated for each location. The data were used to construct cotidal charts and describe characteristics of the predominant diurnal tide. The pattern of the diurnal partial tides on the shelf is explained by reflection of first-class waves propagating normal to the coast. The period of the K_1 tide equals the inertial period just offshore of Mississippi Sound. The resulting diurnal shelf currents are Sverdrup waves with typical speeds of 5-10 cm sec^{-1}. The tidal wave is transformed into a rectilinear shallow-water wave as it enters the tidal inlets of Mississippi Sound. The form number of the shelf currents changes from 8.5 to 2.1 in the inlets due to enhancement of the semidiurnal currents. This is a result of continuity constraints, which transform currents in the inlets. Within Mississippi Sound, the tidal waves shoal and become increasingly progressive in response to bottom friction. (27 refs)

Seng, L. T., Kwong, L. Y., Chye, H. S., Huat, K. K., Pheng, K. S., Hanapi, S., Meng, W. T., Legore, R. S., de Ligny, W., and Tan, G. T. 1987. Effects of a crude oil terminal on tropical benthic communities in Brunei. (See complete entry in Section IV.)

Sengupta, S., Miller, H. P., and Lee, S. S. 1981. Effect of open boundary condition on numerical simulation of three-dimensional hydrothermal behavior of Biscayne Bay, Florida. (See complete entry in Section VI.)

Sha, L. P. 1989. Sand transport patterns in the ebb-tidal delta off Texel Inelt, Wadden Sea, The Netherlands. (See complete entry in Section II.)

Sheng, Y. P. 1986. Numerical modeling of coastal and estuarine processes using boundary-fitted grids. (See complete entry in Section VI.)

Sheng, Y. P. 1986. Second-order closure modeling of turbulent flow and sediment dispersion in coastal and estuarine waters. (See complete entry in Section VI.)

Sheng, Y. P., and Butler, H. L. 1982. A three-dimensional numerical model of coastal, estuarine, and lake currents. (See complete entry in Section VI.)

Sherwin, T. J. 1988. Analysis of an internal tide observed on the Malin Shelf, north of Ireland. (See complete entry in Section I.)

Shideler, G. L. 1984. Suspended sediment responses in a wind-dominated estuary of the Texas Gulf Coast. (See complete entry in Section II.)

†**Simon, M. M. B., and Goutorbe, F.** 1983. Manual method of calculating tides taking into account principles of harmonic constituents. (Mèthode de calcul manuel de la marée à partir des principales constantes harmoniques). *Annales Hydrographiques* 11(758):17-31 (In French).

The tide is shown with the helo of the waves 0_1, K_1, M_2, and S_2 to which corrections are applied by means of diagrams and tables in order to take account of the other important waves. The method is well suited to manual reckoning from those harmonic constituents supplied by Service Hydrographique et Oceanographique de la Marine publication n° 540 for some 850 ports: The World's Major Ports General Tide Table.

†**Sivakumaran, K.** 1989. Selection of modeling and monitoring strategies for estuarine water quality management. (See complete entry in Section VI.)

Smith, P. E., ed. 1982. *Proceedings of the Conference applying research to hydraulic practice.* (See complete entry in Section I.)

Snowden, R. J., and Ekweozor, K. R. 1987. The impact of a minor oil spillage in the Estuarine Niger Delta. (See complete entry in Section IV.)

Snyder, R. L., Sidjabat, M., and Filloux, J. H. 1979. A study of tides, setup and bottom friction in a shallow semi-enclosed basin; Part II: Tidal model and comparison with data. (See complee entry in Section VI.)

Stacey, M. W., and Zedel, L. J. 1986. The time-dependenty hydraulic flow and dissipation over the sill of observatory inlet. (See complete entry in Section VI.)

Stelling, G. S., Wiersma, A. K., and Willemse, J. B. T. M. 1986. Practical aspects of accurate tidal computations. (See complete entry in Section VI.)

†**Stelling, G. S., Willemse, J. B. T. M., and Rozendaal, A.** 1986. A computational model for shallow water flow problems on the Cyber 205. (See complete entry in Section VI.)

Sternberg, R. W. 1979. Bottom-current measurements and circulation in Western Port, Victoria. *Marine Geology* 30(1/2):65-83.

Bottom-water movements in Western Port, Victoria, were investigated as part of the Westernport Bay Environmental Study. Instrumented tripods were used at nine stations to collect data on bottom currents, tidal conditions, and wave activity in the major channel system of the bay. Bottom currents generated by tides ranged up to 70 cm/sec. The ratio of tidal range to half-tidal period ($\Delta H/\Delta T$) was compared with measured currents to provide a basis for prediction of the annual frequency distribution of maximum bottom-current velocities. Flow directions do not always conform to channel alignments, and deviations are important. Net flows at the stations indicate patterns of ebb and flood dominance and a clockwise net circulation around a large central island. Wave activity was generally insufficient to generate bottom pressure flucutuations, except in the exposed western entrance which opens to Bass Strait. (4 refs)

Sternberg, R. W., Caccione, D. A., Drake, D. E., and Kranck, K. 1986. Suspended sediment transport in an estuarine tidal channel within San Francisco Bay, California. (See complete entry in Section II.)

Stevenson, J. C., Ward, L. G., and Kearney, M. S. 1988. Sediment transport and trapping in marsh systems: Implications of tidal flux studies. (See complete entry in Section II.)

Storni, M. S. O., Lara, R. J., and Pucci, A. E. 1984. Tidal variations of some physico-chemical parameters in Blanca Bay, Argentina. (See complete entry in Section III.)

Su, J., and Wang, K. 1986. The suspended sediment balance in Changjiang Estuary. (See complete entry in Section II.)

Su, T. Y., Trujillo, J., Yue, J. P., and Wang, S. Y. 1986. Multilevel finite element simulation of sediment transport in Mobile Bay. (See complete entry in Section II.)

†**Summers, L., and Clifford, J. E.** 1981. Maritime investigations for artificial islands. (See complete entry in Section I.)

Swain, A., and Houston, J. R. 1985. A numerical model for beach profile development. (See complete entry in Section VI.)

†**Swift, M. R., and Brown, W. W.** 1983. Distribution of tidal bottom stress in a New Hampshire estuary. (See complete entry in Section I.)

†**Taft, J. L.** 1984. Chesapeake Bay nutrient dynamics study. (See complete entry in Section II.)

Tait, B. J., Grant, S. T., St.-Jacques, D., and Stephenson, F. 1986. Canadian Arctic tide measurement techniques and results. (See complete entry in Section VII.)

Tang, Y., and Tee, K.-T. 1987. Effects of mean and tidal current interaction on the tidally induced residual current. (See complete entry in Section VI.)

Tee, K.-T. 1981. A three-dimensional model for tidal and residual currents in bays. (See complete entry in Section VI.)

Tee, K.-T. 1985. Depth-dependent studies of tidally induced residual currents on the sides of Georges Bank. (See complete entry in Section VI.)

Tee, K.-T., and Lim, T.-H. 1987. The freshwater pulse--A numerical model with application to the St. Lawrence Estuary. (See complete entry in Section VI.)

Teeter, A. M., and Hauck, L. M. 1989. An ongoing investigation of residual suspended material transport in central San Francisco Bay, CA. In *Hydraulic engineering,* Proceedings of the 1989 National Conference on Hydraulic Engineering, 14-18 August 1989, New Orleans, LA, ed. Michael A. Ports, 499-504. New York: ASCE.

A study of suspended material transport in San Francisco Bay, California, is presently underway by the US Army Corps of Engineers. This paper describes preliminary numerical model and prototype data collection results and the computation of suspended material fluxes. Thus far, one field survey has been performed. Vertically averaged, finite-element, numerical hydrodynamic, and transport models have been applied. Preliminary indications are that suspended material transport rate and direction through the central bay area can be highly variable during summer low freshwater inflow conditions. (7 refs)

Teisson, C., and Latteux, B. 1986. A depth-integrated bidimensional model of suspended sediment transport. (See complete entry in Section VI.)

ten Brummelhuis, P. G. J., de Jong, B., and Heemink, A. W. 1988. Stochastic dynamic approach to predict water levels in estuaries. (See complete entry in Section VI.)

Thabet, R. A. H., Verboom, G. K., and Akkerman, G. J. 1985. Two dimensional modelling of tidal motion for harbour studies. (See complete entry in Section VI.)

Thabet, R. A. H., and Vlasblom, H. P. L. 1985. Forecasting current velocity on routine basis. (See complete entry in Section I.)

Thomson, J. D., and Godrey, J. S. 1985. Circulation dynamics in the Derwent Estuary. (See complete entry in Section III.)

Thomson, R. E., and Wolanski, E. J. 1984. Tidal period upwelling within Raine Island entrance, Great Barrier Reef. *Journal of Marine Research* 42(4):787-808.

Temperature and current measurements collected from November 1981 to May 1982 at the head of Raine Island Entrance reveal tidally induced upwelling cold continental slope water onto the continental shelf. Daily tidal motions account for approximately 80 percent of the total cross-shelf eddy heat flux of 0.79 ± 1.01 cal cm^{-2} sec^{-1}. Although temperature and current fluctuations are principally of semidiurnal period, the heat flux is principally at diurnal period. Based on empirical nutrieint-temperature relations, the onshore inorganic nutrient fluxes are estimated to be 0.9 ($\pm$1.2) x 10^{-2} mmol m^{2} sec^{-1} for nitrate, 0.6 ($\pm$0.8) x 10^{-2} mmol m^{-2} sec^{-1} for silicate, and 0.7 ($\pm$0.9) x 10^{-3} mmol m^{-2} sec^{-1} for phosphate. The upwelling is explained in terms of fluid withdrawal-type mechanisms in which nutrient-rich thermocline water below 100-m depth is drawn onto the shallow (40 m) shelf during the flood. It is suggested that this tidal period inundation of the outer reefs is an important mechanism for effectively upgrading nominally low nutrient levels. Reef growth is expected to be most prolific near the shelf break where the time-integrated contribution of the upwelling is greatest. (12 refs).

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An array of three current meters were anchored on the continental shelf of the East China Sea during the last half of February 1975 as part of the Japanese Air Mass Transformation Experiment, AMTEX-75. The results indicate that the currents are dominated by the rotational semidiurnal M_2 tidal component superimposed on a slow mean drift to the northeast. Differences in direction of several days duration between two of the current meters suggest the presence of transient mesoscale eddies or meanders in the flow regime. Rotary spectra indicated that the tidal currents are characterized by a clockwise ellipse of eccentricity ≈ 0.6 and that there was some inertial energy present. The current rose for bandpassed velocity flucutuations (0.2-2 cph) was elongated in a direction 25-30 deg to the right of the wind direction indicative of Ekman veering. (11 refs)

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Observations of the residual fluxes of water, salt, and suspended sediment are presented for seven stations along the Tamar Estuary. The data include measurements over single spring and neap tidal cycles, and are generally applicable to medium or high runoff conditions. Surface to bed differences in salinity are typically of the order of several parts per thousand. Gravitational circulation is an important component of residual flow in the deep, lower reaches of the estuary. Here, Stokes drift is insignificant. In the shallow upper reaches, the major residual currents are generated by Stokes drift and freshwater inputs. Data are compared with predictions from Hansen and Rattray's model of estuarine circulation. Salt fluxes due to tidal pumping and vertical shear are directed upestuary at spring tides, tidal pumping being dominant. Tidal pumping of salt is also directed upestuary at neap tides, although it is insignificant in the lower reaches, where vertical shear dominates. Tidal pumping of suspended sediment is directed upestuary near the head at spring tides, and probably contributes to the formation of the turbidity maximum. The existence of the turbidity maximum is predicted using a simplified model of the transport of water and sediment. The model shows that an additional mechanism for the existence of the turbidity maximum is an upestuary maximum in the tidal current speeds (and thus resuspension). In the lower reaches, transport of suspended sediment is directed downestuary at both spring and neap tides, and sediment is essentially flushed to sea with the freshwater. (39 refs)

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The creation of the Kislogubsk tidal power station (TPS) by the floated-in method marked a turning point in the solution of the problem of utilizing tidal energy. Investigations of the TPS during the 5 years before being put into operation, during construction, and then during 20 years of operation made it possible to check new designs, equipment, materials, and methods of protecting them for designing large TPSs. This article examines the main directions of these investigations and their results. (8 refs)

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†**Voorhis, A. D., Epifanio, C. E., Maurer, D., Dittel, A. I., and Vargas, J. A.** 1983. The estuarine character of the Gulf of Nicoya, an embayment on the Pacific Coast of Central America. *Hydrobiologia* 99(3):225-237.

Hydrography and exchange processes in a tropical estuary, the Gulf of Nicoya, Costa Rica, are described from data collected in 1979 and 1980. The measurements and analyses were made in both the dry season and wet season and include temperature, salinity, and density at twenty locations in the gulf and currents (over a semidiurnal tidal cycle) at five locations. Circulation in the lower gulf shows a marked east-west asymmetry due to the predominant runoff along its eastern shore from Rio Barranca and Tarcoles. The freshened surface water from the upper gulf combines with the runoff from these rivers and flows southward along the eastern side of the lower gulf. This flow is compensated by a northward flow of more saline water on the western side at all depths and on the eastern side along the bottom.

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Measurements of velocity and salinity for parts of a flood and an ebb tide in the Conwy Estuary have been used to evaluate the time-dependent longitudinal dispersion coefficients due to vertical and transverse oscillatory shear effects. The values have been compared with semianalytical predictive formulats. Simple empirical expressions are suggested for relating the dispersion coefficients to hydraulic parameters for the conditions observed. (13 refs)

West, J. R., and Oduyemi, K. O. K. 1989. Turbulence measurements of suspended solids concentration in estuaries. (See complete entry in Section VII.)

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Measurements of salinity perturbations in a partially mixed estuary have been used to evalaute the usefulness of an inductive salinometer and to determine some of the characteristics of the salinity perturbations. The salinometer performed satisfactorily under most conditions. Although internal wavelike effects were present, the turbulence fluctuations were dominant. The salinity fluctuations and the turbulent fluxes *sw* and *su* were found to behave in a manner similar to the density fluctuations in a thermally stratified atmospheric boundary layer and a laboratory open-channel flow. A quadrant analysis suggested that the contribution of each quadrant to the turbulent flux changed with Richardson number. The turbulence parameters η and c_γ were found to decrease and increase respectively as Ri increases. (28 refs)

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Sea level and current data are used to show that, at least for the dominant semidiurnal tides, the northern Great Barrier Reef is permeable to tides, the longshore gradients of the phase and amplitude of the tide at the shelf break are very small, and the tidal currents are controlled by the shelf bathymetry. The bulk friction coefficient may be enhanced by the secondary circulation around coral reefs. (14 refs)

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Conventional harmonic tide predictions for the last century have used *f* factors to modify the amplitudes of lunar constituents and u's to correct the constituent equilibrium phases (V_0) as a means of approximating for a given period (1 year or less) the effect of the 18.61-year cycle of the revolution of the moon's node. Historically there was little choice; frition in geared mechanical tide-predicting machines imposed finite limits on the number of constituents used. DOODSON clearly identified and evaluated satellite constituents; his study was updated using the latest

astronomical constants by CARTWRIGHT and TAYLER and by CARTWRIGHT and EDDEN. Nevertheless, satellite constituents, now readily usable on modern computers, have not been used for tide predictions. As a result, predictions have relly been quasi-harmonic, requiring modifying amplitudes and phases periodically, at present every year for US predictions, every 2 months for Canadian, and every 30 days for UK predictions. With satellite constituents, 19 years of hourly tide predictions for Seattle (1921-1939) were computed from initial settings for 1 January 1921. It was not to be expected that the accuracy of harmonic tide predictions would be improved significantly by the new precedure; comparisons of annual residual variances for predictions by US and Canadian procedures indicate that any improvements are small. Nevertheless, this new method removes the need for rather contrived (however clever) procedures, in particular that of constitutents modifying M_1 and L_2 by cycles per 8.85 years (revolution of lunar perigee) in the *f* and *u* corrections for these constituents. (9 refs)

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REPORTS OF COMMITTEE ON TIDAL HYDRAULICS

Report No.	Title	Date
1	Evaluation of Present State of Knowledge of Factors Affecting Tidal Hydraulics and Related Phenomena	Feb 1950
2	Bibliography on Tidal Hydraulics	Feb 1954
	Supplement No. 1, Material Compiled Through May 1955	Jun 1955
	Supplement No. 2, Material Compiled from May 1955 to May 1957	May 1957
	Supplement No. 3 Material Compiled from May 1957 to May 1959	May 1959
	Supplement No. 4, Material Compiled from May 1959 to May 1965	May 1965
	Supplement No. 5, Material Compiled from May 1965 to May 1968	Aug 1968
	Supplement No. 6, Material Compiled from May 1968 to May 1971	Jul 1971
	Supplement No. 7, Material Compiled from May 1971 to May 1974	Jun 1975
	Supplement No. 8, Material Compiled from June 1974 to June 1980	Dec 1980
	Supplement No. 9, Material Compiled from June 1980 to June 1983	Jun 1985
	Supplement No. 10, Material Compiled from June 1983 to June 1986	Jun 1987
3	Evaluation of Present State of Knowledge of Factors Affecting Tidal Hydraulics and Related Phenomena (revised edition of Report No. 1)	May 1965

Technical Bulletin No.	Title	Date
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2	Fresh Water-Salt Water Density Currents, a Major Cause of Siltation in Estuaries	Apr 1957
3	Tidal Flow in Entrances	Jan 1960
4	Soil as a Factor in Shoaling Processes, a Literature Review	Jun 1960
5	One-Dimensional Analysis of Salinity Intrusion in Estuaries	Jun 1961
6	Typical Major Tidal Hydraulic Problems in United States and Rseearch Sponsored by the Corps of Engineers Committee on Tidal Hydraulics	Jun 1963
7	A Study of Rheologic Properties of Estuarial Sediments	Sep 1963
8	Channel Depth as a Factor in Estuarine Sedimentation	Mar 1965
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10	Significance of Clay Minerals in Shoaling Problems	Sep 1966
11	Extracts from the Manual of Tides	Sep 1966
12	Unpublished Consultation Reports on Corps of Engineers Tidal Projects	Dec 1966
13	Two-Dimensional Aspects of Salinity Intrusion in Estuaries; Analysis of Salinity and Velocity Distributions	Jun 1967
14	Tidal Flow in Entrances; Water-Level Fluctuations of Basins in Communication with Seas	Jul 1967
15	Special Analytic Study of Methods for Estuarine Water Resources Planning	Mar 1969
16	The Computation of Tides and Currents in Estuaries and Canal	Sep 1969
	Appendix A: A User's Manual	Jun 1973
17	Estuarine Navigation Projects	Jan 1971
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19	A Field Study of Flocculation as a Factor in Estuarial Shoaling Processes	Jun 1972
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